DEMOGRAPHIC CONCEPTS

FOR RURAL AND URBAN PLANNERS

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Preface

In many planning situations demographic data play an invaluable role. Whether it is in describing or analysing the population characteristics of an area as such, in converting planning parameters (like production, consumption, or service delivery) to per capita levels, or in assessing development indicators, demographic information is a prerequisite. Moreover, the art of making population projections - an important task for any planner- is well rooted in demography.

This teaching paper provides an introduction to demographic terms and concepts. It treats selected aspects of fertility and mortality, migration, population structure, as well as population distribution. As such it forms the basis for an understanding of population projections. Population projections, however, are dealt with in a separate teaching paper (Mbiba and Olthof, forthcoming).

While a number of good textbooks on demography exist that also provide projection techniques, it is believed that this teaching paper will provide a useful addition for two reasons. First, it predominantly uses demographic data from Zimbabwe, at times supplemented by data from other SADCC countries. In this way examples will be better recognised by readers from Zimbabwe and its neighbouring countries. Standard textbooks usually provide the bulk of their examples from European or North-American cases, while the books that exist on Africa (Kpedekpo, 1982; Onokerhoraye, 1985) are illustrated with North and West African figures. Second, this paper pays specific attention to issues at the sub-national level. While the national and sectoral levels are not forgotten, it is felt that a focus on rural, urban or regional aspects is proper as some specific issues come to the fore at the sub-national level, and most books pay only very little attention to them.

The paper has been developed as part of a lecture series on planning techniques in the post-graduate Diploma programme at the Department of Rural and Urban Planning, University of Zimbabwe. Its main target is therefore these Diploma students, but other planning students and practising planners may also find the paper useful. It partly builds on some teaching material earlier developed by Dr. A.H.J. Helmsing and Mr. C. Brand. However, their work has been considerably expanded and updated to form the current manuscript. The paper is therefore the full responsibility of the author and any views expressed exclusively his.

In writing about demography, it is inevitable to use mathematical symbols and notations. To keep the text readible, an attempt has been made to reduce the number of symbols and equations to a minimum. Symbols in demography are not always used consistently and this paper also suffers somewhat from this weakness, although it has been tried to avoid major confusion. However, the reader has to be aware that following international custom the letter "P" has been used both to indicate `population' and `survival ratio'. Survival ratio, on the other hand, is also given the letters "sr". Migration has been assigned the capital letter "M" to distinguish it from mortality ("m").

As mentioned above, this teaching paper can be seen as providing background reading to the teaching paper on population projections (Mbiba and Olthof, forthcoming). However, it can very well be used separately .

I like to thank Mr Joseph Binala and Mr Peter Mafigu for drawing the figures and diagrams.

Any comments on the text or suggestions for improvements will be highly appreciated.

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1. DEMOGRAPHY AND POPULATION STUDIES

Scientists of many disciplines are interested in matters of population: demographers, geographers, economists, planners, historians, sociologists, psychologists, biologists, as well as medical scientists. While all of these disciplines have their own way of analysing and applying population data, they also have a common base in the terms and concepts used, and the interest the description and explanation of population structure and change. In this chapter the fields of demography and population studies are explored. The chapter also presents some basic demographic concepts, and discusses data sources and data quality.

1.1. Basic concepts and definitions

A literal translation of the Greek words `demos' and `graphein' means "to describe people" or "to write about people". Nevertheless demography is concerned with more than only the description of a population. According to Bogue (1969, p. 1) demography is:

> "the statistical and mathematical study of the size, composition and spatial distribution of human population and of changes over time in these aspects through the operation of the five processes of fertility, mortality, marriage, migration and social mobility".

Although there is some dispute as to whether social mobility should be included in the study of populations, it is nevertheless clear that demography has to rely on a number of other disciplines if it is to provide an understanding of the phenomena observed. Any worthwhile interpretation of causes and effects of population change has to include an examination of the social, economic, historical, cultural, and political characteristics of a population (Kpedekpo, 1982, p. 1). When these broader aspects are included one often refers to `population studies' to describe the particular field of study.

The term `demography' is traditionally used in a more narrow sense, dealing with the statistical recording, analysis, and interpretation of births, deaths, and nuptuality. Sometimes a distinction is made between statistical demography, which is primarily concerned with the description of populations and population change and the use of statistical and mathematical techniques therein, and social demography where demographic data are related to socio-economic factors. As such, social demography is closer to `population studies' and statistical demography to `pure demography'.

Besides demographers, traditionally population geographers have also dealt with the description and analysis of populations. Population geographers have mainly studied two particular fields: migration and the spatial variation of demographic variables like birth or death rates or marriage patterns. This concern with spatial variation has been the geographer's distinctive contribution to population studies (Johnston, 1986, p. 355).

However, the traditional boundaries between the specific inputs of geographers, demographers and others have been fading for quite some time now, although old traditions somehow remain in the point of emphasis of the various disciplines. The fact that several disciplines are involved in population studies has three major advantages: first, in conjunction they are better able to provide plausible explanations for the often complex ways in which populations change; second, through the various applications they urge data collectors and demographers to come up with a clear and unambiguous way of defining and recording data; and third, the various ways in which population data are used have led to a recognition of the importance of keeping a good system of population data.

Some basic concepts have to be clear and well-defined to whoever is collecting or using population data. Among the most important is the way in which populations are enumerated or represented. Two possibilities exist: a de jure and a de facto population count. A de jure population refers to the number of people who usually reside in a certain area. Whereas this concept is very useful for administrative and planning purposes (taxation, education, housing etc.), there is ambiguity with respect to the definition of `usually' (or `normally'). For data collection purposes a de facto population is therefore easier and more straightforward to handle. A de facto population refers to people who spent the night at a specified place during a moment of recording (census or otherwise).

The two might differ considerably. In some (subnational) areas people might often be away for work or otherwise, while they still consider themselves as living in the area. In cases of widespread labour migration it might be good to provide both figures (if available) as the difference tells a great deal about temporary population movements. The 1976 census in Lesotho for instance recorded a de jure population of 1217000 and a de facto population of 1064000 (ILO, 1979, p. 18), the difference predominantly made up of labour migrants away in South Africa.

Another important distinction is that between stock and flow data (Kpedekpo, 1982, p. 3). Stock data give a picture of the characteristics of the population at a particular moment in time. Flow data, on the other hand, show how the stock data change over time. Examples of stock data are population by age and sex, occupation, literacy etc., while flow rates refer to data like birth, death and migration rates. The two are sometimes referred to as point data and period data respectively.

1.2. Sources of data

Traditionally there are two main sources from which population figures are obtained: from censuses and from (vital) registration systems. However, other sources, like sample surveys, school, clinic or parish registers, or aerial photographs may provide useful additional information. This is certainly the case in a number of African countries where census data are sometimes inaccurate and registration systems virtually non-existent.

Population censuses form the single most important source of population data in Africa. A population census is the systematic recording of all persons -and some of their characteristics- in a specified territory (usually a nation) at a certain moment in time. This definition implies that a census aims at full spatial coverage of the area under study. In other words: all inhabitants or residents of the census area need to be covered. The definition also points to the fact that a census has to be conducted in a very short time period. As it is a kind of "snapshot picture" of the population the time period has to be minimised in order to avoid "movements". The longer it takes to complete the census the greater the chances are that people will be counted twice or not at all. Of major importance is the way in which someone is enumerated: on a de facto or on a de jure basis (see paragraph 1.1 above). During the 1982 census of Zimbabwe the enumeration took place on a de facto basis, i.e. people were enumerated at the place where they happened to be during the time of the census, irrespective of their usual place of residence (CSO, 1985, p. 1). The period during which the census was conducted was 16 to 27 August 1982, although most people were recorded on the 18th of August. For all purposes the population figures are therefore related to 18 August 1982.

There are various methods in which the census form can be filled in. The head of household (or in his/her absence another adult member of the family) can fill the form on behalf of the household, all adult members may fill in a form, an enumerator can ask questions and record the answers for each household separately, or an entire community may be gathered together and enumerated by specially trained people. Questions asked may also differ. In most censuses people are asked for their age, sex, marital status, place of birth, number of children, income, occupation, religion, and education. In addition other socio-economic variables may be added that are of particular interest to users of the data, like wealth, consumption patterns, or various preferences or tastes.

Registration systems refer to a continuous recording of demographic statistics. A government office at local level may be tasked with entering all changes in population (births, deaths, migration). This is called a vital registration system. Alternatively, or in addition, it may keep a record of all persons living and residing within its boundaries (population registration system). The difference between the systems lies in the fact that a vital registration system generally keeps separate registers for various categories of vital statistics, while a (universal) population register does give a complete picture about individuals in the population, as a personal record is kept for everyone showing vital events and migrations (Onokerhoraye, 1985, p. 19). For Africa, registration systems are of little use to the demographic analyst and planner as complete systems are nowhere to be found. Where they exist they tend to cover only a limited part of the country (mainly urban areas) and a limited part of the population (determined by class, and -in the past- by race).

Population censuses and registration systems may sometimes be supplemented by sample surveys. A sample survey systematically selects a certain percentage of the population. The information obtained on the basis of the answers of this part of the population is then generalised to the total population. An example is the 1987 10% sample survey carried out in Harare, as part of the Harare Combination Master Plan. It is imperative that the sample should be chosen correctly as mistakes in the sample size or coverage could lead to great errors in the final interpretation. Sample surveys in demography can be of two kinds: single round and multi-round surveys (Kpedekpo, 1982, p. 2). The latter refers to repeated visits to the same respondents at regular intervals in order to find out what changes have taken place in the meantime.

Other data sources that are sometimes used for the collection of demographic information are parish registers, registers of schools or clinics, taxation registers, registers at airports, and remote sensing data (in conjunction with field checks). The various registers provide information about a part of the population only, but can be used for a number of analytical purposes (on births, deaths, marriages etc.) which may supplement or replace information of a wider coverage. A rather recent alternative is the use of aerial photographs or even satellite images to make estimations of population size (other composing characteristics are impossible to gather from `above'). On the basis of the number of houses (by type) or certain digitally recorded values and fieldchecks as to their implication in terms of average number of people residing in these houses/areas, it is possible to come up with a reasonably accurate and in any case up-to-date estimation of the total population in an area.

1.3. Quality of demographic data

The quality of demographic data is dependent on both the source of information and the variable concerned. Countries with a long tradition in vital registration systems are often able to provide extremely accurate information. In those countries it is sometimes even superfluous to carry out a census.

A census, on the other hand, is by its very nature -a huge exercise, which must be carried out quickly and by many people- susceptible to errors. There may be omissions (people erroneously left out) or double counts. This may be caused by problems in the delineation of enumeration areas, by the absence of sufficient and sufficiently qualified enumerators and equipment (transport), or by the lack of cooperation of the people to be enumerated. People may refuse to respond, particularly when they do not see the relevance, or foresee abuse of the information provided (taxation). They might also exaggerate or understate certain information or answer in a `socially acceptable manner'.

A particular problem in many censuses is a phenomena called "age-heaping". Age-heaping refers to a pattern in which many more (or less) people than expected report to be of a certain age. This can be caused by the fact that people do not know their exact age, although nowadays it can be reasonably well estimated through the use of historic calendars. There is a particular preference for ages ending at the digits 0 and 5 (like 45, 50 55, 60 etc.). Age shifting is another systematic error (Kpedekpo, 1982, p. 7), which occurs when on a large scale people report ages that are younger or older than their real ages. This might be done for prestigious reasons.

Age heaping and age shifting may be culturally determined, just like for instance the tendency to report children of one sex more completely than those of another. In some cultures male descendants are seen as more important than female offspring, which causes people to exaggerate the number of sons and/or understate the number of daughters. On another note, people may not want to provide information on family members they see as problematic in one way or another (handicapped, criminal record etc.).

An important problem with census is also the time that elapses between the census is conducted and the publication of the first results. It often takes several years before the first, preliminary reports are published, while both the publicum and the users (planners, politicians etc.) usually need the data straightaway.

A common weakness in both vital statistics and census data is the failure to supply certain information (Pressat, 1978, p. 6). This may be caused by factors such as illiteracy and misunderstanding, but it may also refer to information of the more sensitive kind. People may be unwilling to provide data on questions which refer to sad occasions (death of a child) or to situations they are ashamed of (low achieved level of education). In those cases the information may simply not be provided (and will hence be registered under the title `not stated' or `unknown') or be inaccurate. The advance report (based on a 10% sample) of the Zimbabwean 1982 census remarks for instance on the lower than expected Infant Mortality Rates: the most probable explanation is the underreporting of deaths. It is generally known that people do not like to talk about events such as deaths, particularly those which have occurred quite recently" (CSO, 1985, p. 168).

Vital registration systems in Africa are generally incomplete, particularly neglecting the rural areas. In addition, where they exist, people might register very late or not at all, making the information inaccurate. Underregistration is reported as being common in many African countries (Onokerhoraye, 1985, p. 23). Finally, there may be lack of coordination among various agencies dealing with the registration, causing the system to differ from place to place and person to person.

Problems with sample surveys generally refer to the way in which samples are taken. The most obvious problem is the absence of a reliable sampling frame, which in this case is the total population. In the absence of such a more or less accurate sampling frame the sample may be more biased than would happen by pure chance in any random sampling procedure. This will result in some groups receiving a greater coverage than others. Any sample will have some degree of error which is due to the very process of sampling - the fact that only a part and not the total population is covered.

2. POPULATION GROWTH AND DYNAMICS

This chapter provides an introduction to population change, particularly to the growth of population. It first looks at growth factors, and then proceeds to discuss the concept of doubling intervals. In the second part of the chapter two demographic theories are discussed: the demographic transition theory and ~~the~~ Malthus's theory about the relationship between population growth and limited resources.

2.1. Growth Factors

The population change in an area is basically the result of two major factors: natural increase and net migration. Both factors can again be subdivided into two other factors. Natural increase[1] is dependent on births and deaths, while net migration is composed of in-migration minus out-migration. In a formula:

$$G = (B-D) + (I-E) \tag{2.1}$$

where: G = Population Growth
B = Births
D = Deaths
I = In-migration
E = Emigration or out-migration
and (B-D) = Natural Increase
(I-E) = Net Migration

At this stage it is worth noting that one can measure population growth and its components both in absolute and in relative terms. Absolute terms refer to the actual number of people that have been borne, have died, or migrated in a certain period. One can, however, also express the figures in percentages or promillages (relative terms). In that case one usually calculates the births, deaths and population movements as a percentage of the mean (mid-year) population. The Rate of Natural Increase (RNI), the Crude Birth Rate (CBR) and the Crude Death Rate (CDR) are the most commonly used relative measures. The Rate of Natural Increase is defined as the difference between the CBR and the CDR.

The CBR, CDR and RNI are usually expressed as follows:

$$CBR = \frac{\text{total births in a year}}{\text{mid-year population}} \times 1000$$

$$CDR = \frac{\text{total deaths in a year}}{\text{mid-year population}} \times 1000$$

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[1] Usually the words `increase' or `growth' is used, to indicate the normal trend of a growing population, but one can just as well deal with a decreasing population. In that case the net effect of natural growth and migration is negative.

RNI = CBR − CDR

or: $RNI = \frac{\text{total births} - \text{total deaths in a year}}{\text{mid-year population}} \times 1000$

To give an example from Zimbabwe: in 1982, 80 967 deaths were recorded on a mid-year population of 7 472 882. The CDR therefore was calculated as 80967/7472882 x 1000 = 10.8 (CSO, 1985, p. 185).

While the CBR and CDR are expressed per 1000 of the population, the RNI is normally expressed in percentages. On the basis of the 1982 census for Zimbabwe it was estimated that the CBR was 39.5, while the CDR was approximately 10.8. Consequently the RNI was assumed to be 28.7 per thousand, or 2.87%. Figures on CBR, CDR and RNI for selected African countries, based on World Bank figures, are further presented in table 2.

So far the word "Crude" in the CBR and CDR has not been explained. This term indicates that one is working with crude -as opposed to standardised- figures. Crude figures are the ones obtained through a census or registration system and are based on births and deaths related to the actual population. Standardised figures, on the other hand, remove the influence of population composition (see chapter 6) and thus relate the numbers of births and deaths to a reference population. A young population, for example, may very well have a low CDR, simply because of its age structure. If this particular structure is removed, it may very well show a relatively high death rate. To standardise birth and death rates one therefore recalculates births and deaths as if the population had a certain (reference) structure. This facilitates comparison through time or between various areas (countries, provinces, districts).

In every area the population is constantly changing. In other words: we are (nearly) always dealing with a dynamic situation. One way of expressing this dynamic situation is to calculate the annual growth rate of a population. The (average) annual growth rate can be obtained through the following formula[2]:

$$P_t = P_0 (1 + r)^t \qquad (2.2)$$

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[2] this is the same as the normal compound interest formula in business accounting, and is also referred to as the geometric growth method. As the geometric growth method actually adds changes once a year, and population change is a continuous process, it is formally better to use the exponential growth method. However, the geometric method has the advantage of ease of use and the difference in outcome between both methods is marginal. For our purposes the geometric method therefore suffices. For a discussion of the use of both methods see Kpedekpo, 1982, pp. 24-28, while chapter 8 devotes attention to both methods in projections.

where: P_t = Population at the end of a period
P_o = Population at the beginning of a period
r = (average) annual growth rate
t = number of years in the period

This formula can be rewritten as:

$$\frac{P_t}{P_o} = (1 + r)^t$$

or:

$$\frac{P_t}{P_o}^{1/t} = 1 + r \qquad (2.3)$$

or:

$$\sqrt[t]{\frac{P_t}{P_o}} = 1 + r \qquad (2.4)$$

This can be illustrated with an example from Zimbabwe. From census figures the population for Zimbabwe in 1969 (P_o, or P_{1969}) and 1982 (P_t, or P_{1982}) was obtained. In 1969 the population was 5 134 300 and in 1982, 7 472 882. The intercensal period (t) is 13 years. Using formula 2.3 above the average annual growth rate (r) for Zimbabwe in the period 1969-1982 can be calculated.

$$1 + r = \frac{7\ 472\ 882}{5\ 134\ 300}^{1/13}$$

$$= (1.45548)^{1/13}$$
$$= 1.02929$$

Therefore: $r = 1.02929-1$
$= 0.02929$

To express it in percentages one has to multiply the outcome with 100%. This will give the average annual growth rate as 2.9% for the period 1969-1982. Note that it is an average figure; the actual growth rates in the various years within this period may have differed from the 2.9%. For a country at large this difference may not be that enormous, but at provincial, district and certainly local level, the average is likely to hide significant fluctuations.

Note also that the exact dates at which the population data were collected (censuses) are of relevance here. In the example above it was assumed that the censuses were held exactly thirteen years apart.

A simplified, though less accurate method for estimating the natural rate of increase is given by formula 2.5:

$$r = \frac{2(P_t - P_o)}{n(P_t + P_o)} \qquad (2.5)$$

where P_o, P_t, r, and n are all defined as before. In fact, the formula can be seen as the difference between populations at two moments in time, in relation to the mean of the populations, taking the period in between into account. For the Zimbabwean population figures, 1969-1982 this formula would yield:

$$r = \frac{2 * (7\,472\,882 - 5\,134\,300)}{13 * (7\,472\,882 + 5\,134\,300)}$$

$$= \frac{2 * 2\,338\,582}{13 * 12\,607\,182}$$

$$= \frac{4\,677\,164}{163\,893\,366}$$

$$= 0.0285 \text{ or } 2.85\%$$

2.2. Doubling intervals

If a population were to continue to grow at a constant growth rate the growth in actual numbers of people would increase constantly. The population would double after a certain number of years, and double again after a similar number of years, and again and again. The period in which a population will double is called the doubling interval. Using compound interest tables one can easily see how long it takes for a population to double in size, at a specified and constant growth rate. Table 1 shows this for various annual growth rates:

Table 1. Doubling intervals at various growth rates.

Annual growth rate (in percentages)	Doubling interval (in years)
less than 0.5	more than 139
0.5 - 1.0	139 - 70
1.0 - 1.5	70 - 47
1.5 - 2.0	47 - 35
2.0 - 2.5	35 - 28
2.5 - 3.0	28 - 23
3.0 - 3.5	23 - 20
3.5 - 4.0	20 - 18
4.0 - 4.5	18 - 16
4.5 - 5.0	16 - 14
5.0 - 6.0	14 - 12

Sources: Baldwin, 1975, p. 6; Price Gittinger, 1973, pp. 106-114.

The table shows that if the Zimbabwean population were to continue to grow at the average rate of 2.9% it would double in about 23 years. In fact, the compound interest tables will show that it is closer to 24 years. The 7 472 882 people of 1982 would therefore become about 15 million in the year 2006 and 30 million in 2030. Likewise has the average population growth for Bulawayo been recorded at 5.9% for the period 1969-1982 (CSO, 1988). This would imply a doubling interval of 12 years. The Bulawayo population could therefore -assuming a constant annual growth rate- grow from 495 317 in 1982 to about 1 million in 1994 and 2 million in 2006!

An easy way to estimate the doubling interval is to make use of the formula:

$$\text{doubling interval} = 70/r \qquad (2.6)$$

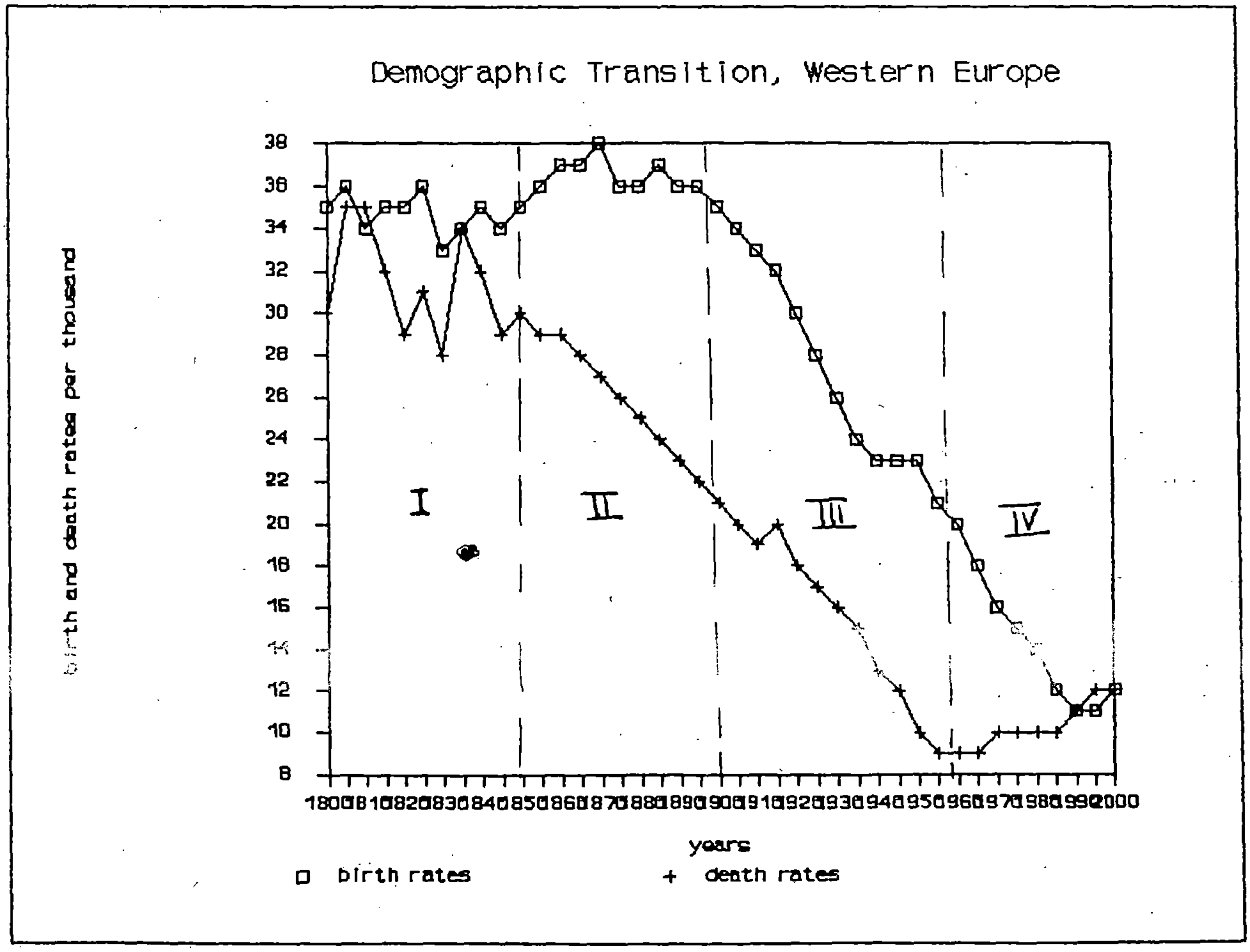
where r is the rate of growth in percentage terms.

2.3. The demographic transition

It is a rare situation to observe a country experiencing constant growth rates for a prolonged period of time. Most countries nowadays see their growth rates declining due to family planning programmes, the spread of education and/or an increase in wealth (see also chapter 3).

On the basis of demographic statistics from the "developed countries" it has been suggested that all countries would follow a more or less similar pattern with respect to their birth and death rates, and consequently their growth rates. Figure 1 shows this demographic transition pattern graphically. The transition has been subdivided in four periods (I–IV).

Figure 1



In the first (pre-transitional) period birth and death rates are fluctuating at a high level. Mortality is high as there is little medical care or knowledge. Absence of birth control makes fertility also high, although it is somewhat reduced through high death rates of women in the reproductive ages. Consequently, the long term population growth rate is extremely low (around 0.5%) and periods of growth are replaced by periods of decline. In Western Europe this period ended somewhere in the mid 19th century.

In the second period (the early transitional stage) death rates started to drop due to improved public health, better diets and higher incomes (Todaro, 1989, p. 214-215). At the same time birth rates remained high, and in some cases even rose as a result of better maternal health. The result of these high birth rates and falling death rates was a rapid increase in population growth rates (to about 2.0% a year). The demographic transition had started. In Europe this period can roughly be pictured as 1850-1900.

The third period (intermediate transitional stage) showed a continuation of the falling death rates, but now also the birth rates started to drop. Factors responsible for this drop were higher income levels, availability of contraceptives, diminished influence of churches etc. As a consequence population growth rates continued at a relatively high and stable level (2.0-2.5% a year). This period went on until the middle of the 20th century, although some countries entered the first phase somewhat earlier, others a decade or two later.

The fourth and last period of the demographic transition, the late transitional stage, is characterised by low and stable death rates and continually falling birth rates. Medical technology is widespread in society but the now prevalent causes of death (cancer, heart problems) are more difficult and expensive to overcome than in the earlier stages when mortality could be reduced through inoculation campaigns and improved water supply and public health in general. The continued drop in birth rates is, amongst others, ascribed to an increased acceptance of family planning and contraceptives, and an increase in women's education and labour participation rates. Population growth rates are significantly reduced (around or even below 1.0%) and shows a tendency to zero.

Sometimes a fifth period (the post-transitional stage) is distinguished. In this stage birth and death rates remain low and relatively constant. Death rates may slowly rise due to the "greying" of a country. As birth and death rates tend to offset each other, population growth is very low, if existent at all. Some countries, like (West-)Germany in the 1980s, actually showed a negative natural rate of increase.

Whether the demographic transition model is applicable to Africa is disputable. First, birthrates in Africa have always been higher than in Europe where late marriage and celibacy were more widespread. In Africa women tend to marry, or at least get their first child, at an early age. As a result there are more families and a longer period in which to have children. Influenced by imported modern medical equipment and by public health measures death rates in most countries have fallen considerably, which would indicate that they have entered the second phase of the transition. The growth rates, however, are much higher than they have ever been in Europe, and in most African countries well above 2.5%. Table 2 shows the birth and death rates for selected African countries in 1965 and 1987, as well as their rates of natural increase.

Table 2. Birth, death, and population growth rates in 1965 and 1987, selected African countries.

Country	Birth Rates		Death Rates		Rate of Natural Increase	
	1965	1987	1965	1987	1965	1987
Botswana	53	35	19	10	3.4%	2.5%
Ethiopia	43	48	20	18	2.3%	3.0%
Ghana	47	46	23	15	2.4%	3.1%
Kenya	52	52	20	11	3.2%	4.1%
Malawi	56	53	26	20	3.0%	3.3%
Nigeria	51	47	23	15	2.8%	3.2%
Tanzania	49	50	22	14	2.7%	3.6%
Uganda	49	50	19	17	3.0%	3.3%
Zambia	49	50	20	13	2.9%	3.7%
Zimbabwe	55	44	17	11	3.8%	3.3%

Source: World Bank, 1989, p. 216.

As the table shows, in most countries the death rate is approaching European standards, while birth rates have remained high, or even increased. In many countries the rate of natural increase has therefore increased over the years, Zimbabwe and Botswana being exceptions.

2.4. Malthusian and other constraints to population growth.

Many people are concerned with the rapid population growth that has been taking place in many parts of the world over the last decades. They question whether the earth will be able to feed ever increasing numbers of people, and are convinced that it will negatively affect human wealth and welfare. In short: they see it as an obstacle for economic development. On the other hand it has been argued that growing populations are an essential ingredient to stimulate economic growth (Todaro, 1989, p. 204-205). Increasing numbers of people imply an increasing demand, which is favourable for economies of scale, and will provide sufficient low cost labour. Also, a growing population is usually a young population, a characteristic generally seen as related to innovative and active. Further, it is argued, not all countries need to worry about man-land ratio's. Particularly in Africa many countries are still sparsely populated and population increase may in fact benefit the development of some areas more than it harms them.

In the 18th century, the Reverend Thomas Malthus, postulated a theory on the relation between population growth and the development of economic resources, which is still being referred to today. Malthus asserted that a human population has the tendency to grow at a geometric rate, while the economic resources, in particular food, would only expand at an arithmetical rate[3]. As a result the growth in food supplies could not keep pace with population increase, agricultural incomes and food consumption would fall, and the population would experience hunger and starvation. The reason why food supplies would grow slowly, compared to population, was seen as the limited amount of good agricultural land available. As more and more people had to be absorbed on the land, marginal land had to be developed, if there was any land left at all. People would therefore have less (productive) land to work on and the marginal labour productivity would actually decline.

Malthus therefore urged people to engage in "moral restraint" and practice birth control (`preventive' checks). If these checks were absent, `positive' checks (starvation, diseases, war) would be inevitable to restrain population growth. Yet, at that time in Europe in the 19th and 20th century neither `preventive' nor large scale `positive' checks occurred. This can be explained by three factors, which the theory did not take into account:

(1) *technological progress*. In the 19th and 20th century a continuing series of inventions and innovations happened, a good deal of them in agriculture. These innovations (ploughs, tractors, high quality seeds) caused the agricultural labour productivity not to decline, but to increase dramatically. Likewise, although land quantity was limited, its quality could considerably be improved through drainage, irrigation, fertilizers etc. The result has been a highly productive agricultural sector where only a limited percentage of the population (in some cases less than 5% of the labour force) is able to feed an entire nation.

(2) *type of economy*. In Malthus' days agriculture was still the mainstay of most people. In subsequent decades, however, the industrial revolution took place and absorbed many people in industrial activities. Through trade products could be exchanged, which is true at the individual level, but also at the level of nations. This explains for instance why a country like Singapore, densely populated with 2.6 million people on less than 1000 km^2, and with only a tiny agricultural sector, is able to feed its population.

(3) *large scale emigration*. At the end of the 19th century, when population pressure was indeed felt in Europe the option existed for large-scale emigration to countries like the United States, Canada, South Africa and Australia.

While large scale emigration may currently not be an option for African countries, the other two factors are certainly good

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[3] a geometric rate is comparable to a compound rate of interest (see 2.1), and implies that a population doubles in a specified period. The series 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024 etc. is an example of a geometric progression.
An arithmetical progression on the other hand is of the type 2, 4, 6, 8, 10, 12, 14 etc. In other words: in each period there is an increase of an equal amount.

possibilities to avoid the `positive' Malthusian population checks. At the moment it seems that economic aspects, particularly the place of African countries in the World economic system, are of more importance than population growth rates in explaining issues of poverty and underdevelopment. Logan (1991, p. 49) puts it this way: "standards of living in Africa are likely to be more closely associated with the mechanisms of domestic and international resource exchange than with demographic parameters such as population growth rates". The orthodox Malthusian thinking can therefore be done away with as too simple. Hunger and starvation should be seen as mainly caused by economic factors, not merely demographic.

3. FERTILITY AND REPRODUCTION

The Crude Birth Rate, discussed in chapter 2, is a simple, but very adequate measure when one wants to analyse how much births contribute to overall population growth. However, when one is eager to compare levels of fertility over various years, or among areas, it is not very appropriate. This is caused by the fact that CBR's are influenced by a population's structure in age, sex and marital status. A population with relatively few women in the reproductive ages will have a lower CBR than a population with relatively more women in those age groups, even if both populations have the same rate of childbearing per woman. In this chapter some measures of fertility and reproduction are presented, which do not have the drawbacks of the CBR and hence are more useful for comparisons.

3.1. Fertility rates

When talking about fertility it is useful first to define the term and to distinguish it from fecundity. The latter is a biological term and expresses the ability of a woman to bear children. In demography, however, we are more interested in fertility: the actual bearing of children by women in the reproductive or fecund ages. The reproductive age is variously defined as 15-44 or 15-49[4], while also girls giving birth before their 15th year are no exception. The fact that one is only looking at women in the childbearing ages effectively eliminates the effect of age composition of a population. Even then, the level of fertility varies per age group within the fecund period, reflecting variations in social influences, like age at marriage, customs about family size, child spacing and use of contraceptives (Baldwin, 1975, p. 36).

Of the measures of fertility we will discuss here (i) the General Fertility Rate (GFR), (ii) the Age Specific Fertility Rate (ASFR), and (iii) the Total Fertility Rate (TFR). For other measures of fertility see for instance Kpedekpo (1982) and Pressat (1978).

The <u>General Fertility Rate</u> (GFR) expresses the number of live births in a year, per 1000 women in the reproductive ages, or:

$$GFR = \frac{\text{No. of live births in a year}}{\text{No. of women, 15-49}} \times 1000$$

On the basis of a 10% sample of the 1982 population census the GFR for Zimbabwe was estimated to be close to 176 in 1982. This is a rather high figure and shows that Zimbabwe is among those countries in the world where the level of fertility is relatively high (CSO, 1985, p. 136). It can also be calculated from table 3 below, by dividing the number of births by women in the 15-49

[4] The latter being the case for Zimbabwe, and most developing countries in general.

cohorts (283 900) by the number of women in the age group 15-49 (1 626 565), which yields a GFR of 174.5[5].

Within the reproductive female age group, however, frequency of childbearing varies considerably from one age group to another. This variation can be expressed by calculating the <u>Age Specific Fertility Rate</u> (ASFR) for the various age groups. The ASFR relates the number of live births occurring to women of a particular age (group) to the number of women of that age (group). Usually one calculates ASFR's per five year age group (cohort), but one can of course also determine them per year. The 5-year ASFR's are applied in the cohort survival method of population projections. Some other important measures, like the Total Fertility Rate and the Gross Reproduction Rate are based on ASFR's.

Symbolically, one can express the ASFR as:

$$ASFR_{x-y} = \frac{\text{No of live births for women in age group x-y}}{\text{No of women in age group x-y}} \times 1000$$

where x-y is the specific age group under study (usually 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, or 45-49). Note that in this formula the fertility rate is again expressed per 1000, although in some cases it is presented per woman, and therefore the multiplication by 1000 can be excluded.

The calculation of ASFR's for Zimbabwe is presented in table 3 below.

Table 3. Calculation of Age Specific Fertility Rates per woman for Zimbabwe, 1982.

Age group	No. of women	No. of live births	ASFR
10-14	516 626	445	0.0009
15-19	410 929	37 373	0.0909
20-24	362 716	93 598	0.2580
25-29	279 915	70 874	0.2532
30-34	205 918	46 291	0.2248
35-39	169 477	27 915	0.1647
40-44	138 961	12 933	0.0931
45-49	109 940	4 126	0.0375
Total:	2 194 482	293 555	1.1232

Source: CSO, 1985, p. 138.

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5 This figure differs slightly from the one presented above. The difference is believed to be caused by some adjustments made by the CSO in order to obtain more reliable figures on births and number of women on the basis of the 10% sample.
One can also calculate the GFR for the age group 10-49, and for the group 15-44, which will be higher than the GFR for the 15-49 group in the first case and lower in the second.

research has shown that there is generally a high correlation between CBR, GFR and TFR, which may be useful in checking demographic data.

3.2. Reproduction rates

While fertility rates are informative measures about childbirth among women in their reproductive ages, they do not tell us the rate at which the population is replacing itself. To determine this reproduction (or replacement) rate one looks at the number of daughters that are borne to replace their present mothers.

The <u>Gross Reproduction Rate</u> (GRR) can be defined as the average number of daughters a woman would bear if she passes through her fecund life span and experiences a given set of Age Specific Fertility Rates. The calculation is the same as for the Total Fertility Rate, except that now only female births are considered, instead of all births. The result will therefore be close to half the TFR. An example of its calculation is given in table 5.

<u>Table 5. Gross Reproduction Rate, Zimbabwe, 1982.</u>

Age group	No. of women	No. of live female births	Age specific female birth rates
10-14	516 626	270	0.0005
15-19	410 929	19 266	0.0469
20-24	362 716	47 767	0.1317
25-29	279 915	35 691	0.1275
30-34	205 918	23 074	0.1121
35-39	169 477	14 013	0.0827
40-44	138 961	6 173	0.0444
45-49	109 940	2 142	0.0195
Total:	2 194 482	148 396	0.5652

GRR = 0.5625 x 5 = 2.826[6]

Source: CSO, 1985, p. 138.

Alternatively, the GRR can be calculated making use of the sex ratio at birth (see chapter 6), through the following formula:

$$GRR = \frac{TFR}{(1 + \text{sex ratio at birth}/100)} \quad (3.1)$$

6 This is a slight decrease compared to the figure for 1981, in which the GRR was calculated as 2.9157, see table VI.3 (CSO, 1985, p. 135).

Given that the sex ratio at birth in Zimbabwe in 1982 was about 97.8[7], the GRR would be: $\frac{5.616}{(1+0.978)} = 2.83$[8]

While the GRR is a very useful measure of replacement, two factors are not taken into account: (i) a certain number of women do not survive through their entire childbearing period, and (ii) a number of baby girls will not live up to the fecund ages. Some measure of mortality thus has to be introduced. This is what the Net Reproduction Rate (NRR) does. The NRR is virtually the same as the GRR, but allows for mortality among women up to the end of their reproductive years. The NRR can be described as the number of future mothers being borne out of present mothers.

Table 6. Calculation of NRR for Zimbabwe, 1982.

Age group	Age specific female birth rate per 1000[a]	% surviving from birth to midpoint of age group[b]	Expected female survivors to age of mother
10-14	0.5	0.89008	0.45
15-19	46.9	0.88106	41.32
20-24	131.7	0.86999	114.58
25-29	127.5	0.85629	109.18
30-34	112.1	0.83918	94.07
35-39	82.7	0.81762	67.62
40-44	44.4	0.79058	35.10
45-49	19.5	0.75658	14.75
			477.07

$$\text{NRR} = \frac{477.07 \times 5}{1000} = 2.38$$ [9]

Notes: [a]: taken from table 5.
[b]: calculated from table VII.10 (CSO, 1985, p. 179) by averaging the l(x) of two subsequent five year interval years, e.g. 10 and 15, or 15 and 20 etc.

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[7] Calculated on the basis of table VI.3 (CSO, 1985, p. 135). This report, based on the 10% sample, mentioned that the sex ratio at birth was in the range of 98-100, a rather low level, as a value of 105 is universally expected (p. 40).

[8] Differences with the GRR calculated above may be due to rounding of TFR and sex ratio at birth.

[9] This is the same figure as the CSO presented in table VI.7 (1985, p. 146), although the CSO did not take the 10-14 age group into account. The effect of this group is rather negligible anyway.

The method of calculating the NRR involves the use of mortality rates (see chapter 4) to determine the chance that a baby girl will survive up to the age of her mother. Chances of surviving up to say 15 years, are of course higher than up to 45 years. These kind of chances are called `survival factors'. The calculation of the NRR is illustrated in table 6 above.

An NRR of 2.38 means that, at the fertility and mortality rates for 1982, a woman who has passed through her reproductive period will have had on the average 2.38 daughters, who in turn will live up to the age of their mothers and are assumed to be future mothers. Or: 1000 mothers will, after one generation, be replaced by 2380 future mothers. This again means that the Zimbabwean population will more than double itself within a period of one generation.

In general, if the NRR is less than one, the population will have a declining tendency, while an NRR of 1 points at a stationary population. If the NRR is above 1 the population under study will grow. The NRR can also be used for population projections.

One should, however, keep in mind that the NRR is dealing with so-called synthetic cohorts, and not with actual cohorts. A synthetic cohort is a hypothetical concept of an age group that is assumed to experience the <u>current</u> demographic phenomena (fertility, mortality) while it passes through time. The NRR is thus calculated on the basis of fertility and mortality rates computed on data of a single year, and it is assumed that these rates will remain constant when the new borne daughters will live through their reproductive life. This is not what is likely to happen in reality as changing social and economic conditions and customs will influence fertility and mortality. The actual reproduction of the cohort of new born baby girls will therefore always differ from the NRR. We should therefore be careful with the interpretation of the NRR. It merely tells us the extent to which women <u>would</u> reproduce themselves, <u>if</u> the current age specific fertility and mortality rates continue without change for at least one generation (Baldwin, 1975, p. 65-66; Kpedekpo, 1982, p. 63-64).

4. MORTALITY AND LIFE TABLES

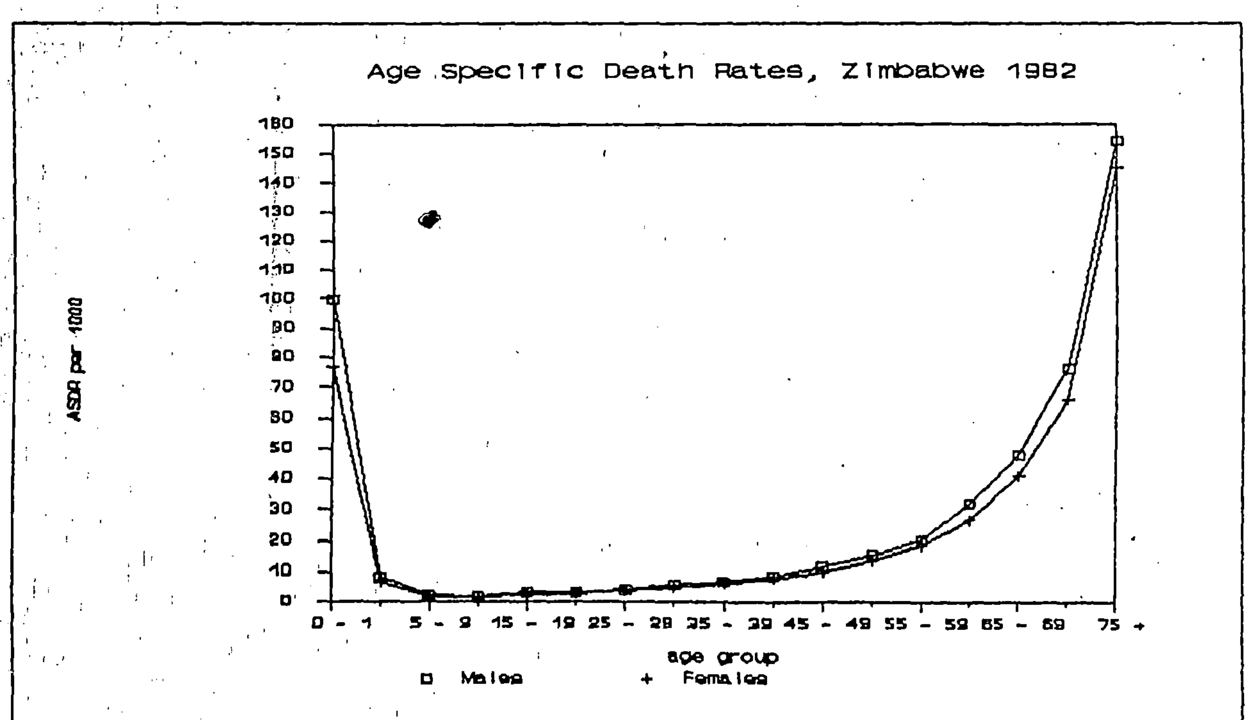
The Crude Death Rate, like the Crude Birth Rate, is influenced by the age structure of the population. In chapter 3 we discussed the concepts of fertility and reproduction, which were designed to overcome this drawback. In this chapter mortality and survival rates will be presented, which also effectively remove the influence of age structure on death rates. In addition, the concept of life expectancy and the function of life tables will be dealt with.

4.1. Mortality and survival rates

The Crude Death Rate (CDR) is the simplest measure of mortality, but -as stated before- severely distorted by variations in age structure of a population. Young populations will generally have lower CDRs than populations with relatively more people in the higher age classes. The <u>Age Specific Death Rates</u> (ASDRs), on the other hand, state mortality levels per age group. An ASDR expresses the number of deaths of persons of a certain age group per 1000 of the population in that age group (Johnston et al., 1986, p. 306).

Mortality, and therefore the ASDR, varies over the ages. It is generally highest in the first year, and then decreases sharply. It starts to rise again after the age group 10-14, first slowly, then more sharply. Figure 2 shows that the ASDRs for Zimbabwe, 1982, display a similar pattern as reported elsewhere (see Baldwin, 1975, p. 45; Kpedekpo, 1982, p. 77 for rural Nigeria).

<u>Figure 2</u>



As the figure shows the ASDRs for women are somewhat lower than for men, indicating that in each age category a higher proportion of males is likely to die. Alternatively, the chance of survival in each age group is higher for females than for males.

Mortality rates for the age groups under 1 and 1-4 deserve special attention. The first is called the Infant Mortality Rate (IMR), the second the Child Mortality Rate. The IMR is a widely used measure, and is generally seen as an indication of a country's or region's overall development. It is determined by dividing the number of infant (under 1 year) deaths by the number of live births in the same year (Onokerhoraye, 1985, p. 70). However, although useful and widely applied, this measure is not completely satisfactory as it includes deaths of children under 1, borne in the previous year. One can take this group into account by dividing by a weighted mean of births, i.e. the mean of the births in the year under study and the previous year, weighted for the proportion of deaths resulting from this year's births versus previous year's births. For a more elaborate discussion and a worked-out example, see Pressat (1978, p.46). Other methods of estimating infant mortality rates are discussed in Kpedekpo (1982, pp. 82-87). The Child Mortality Rate is defined as the number of deaths among children between 1 and 4 years old, divided by the living mid-year population of children between 1 and 4.

According to the Whitsun Foundation (1983, p. 74-75) there are considerable variations in Infant Mortality Rates between the various districts of Zimbabwe. IMRs for around 1980 have been reported to range from 68 per 1000 in Bikita, to 300 per 1000 in Binga District.

It appears difficult to determine the IMRs using census data. For Zimbabwe, the CSO mentions serious underreporting of infant deaths, presumably caused by the reluctance to talk about sad events, like deaths, particularly those of a recent date. Demographers have designed various methods to overcome this and other problems (see CSO, 1985, p. 170-173). According to these estimates in 1982 the IMR was somewhere between 73 and 98 per 1000.

Survival rates are simply the opposite of mortality rates. Where a mortality rate tells us the percentage of people (of a certain age) that die in a certain period (usually 1 or 5 years), a survival rate indicates the percentage that survives. The calculation of survival rates is based on the ASDRs. Obviously, a survival rate can be computed by subtracting the mortality rate from 1 (or 100%). If p_x is the survival rate for a certain age group, and m_x the mortality rate, then by definition:

$$p_x = 1 - m_x \qquad (4.1.)$$

Survival rates should not be confused with survival ratios (see paragraph 4.2. below). The latter are used in population projection methods, notably the cohort-survival method. Both can usually be obtained from life tables, either directly or indirectly.

The Child Survival Rate, the percentage of those born who survive to the age of 5, needs special attention as it is seen as an important measure in a country's or region's development. UNICEF considers it to be a more accurate measure of development than the Gross National Product (GNP). The Child Survival Rate is related to the health of mothers and children, which again is dependent on factors like income, public health, water supply, and education. Zimbabwe's Child Survival rate is comparatively high. In the 1980s it increased to above 90%. In the SADCC region the situation was only better in Botswana (see Hifab/Zimconsult, 1989, p. 51).

4.2. Life tables and life expectancy

Probabilities of death and survival for different age groups in a population are usually presented in a life table. A life table gives a statistical overview of what would happen, in terms of death and survival, to a population if the current age specific mortality rates will prevail[10]. One generally takes a hypothetical cohort of 100 000 babies, all born on the same day, and fictitiously exposes it to the mortality conditions of a particular period or moment (a year or a census date). The cohort is then followed until the last surviving member dies. The result is presented in a life table. Separate life tables are usually constructed for males and females, due to the different mortality conditions for each of the sexes. Tables 7 and 8 present the male and female life tables for Zimbabwe in 1982.

While the construction of life tables is rather complicated and a task reserved for professional demographers, planners at least need to be able to make interpretations of life tables. Moreover, they should be aware which data of a life table can be usefully applied in day to day practice. The main functions of life tables are therefore outlined below.

A life table is composed of several columns, each related to the others. Figures in each column are different for each age. Age is usually denoted by the suffix `x', and either refers to the birthday at the beginning of the age interval or the age interval as such. Variables and symbols one might encounter in a life table are:

* the age specific mortality rate (m_x);
* the probability of dying within a given age interval; or the life table death rate (q_x);

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10 In this paper only the conventional life table is dealt with, as this life table is widely applied for population projection purposes. For a comparison with the generation life table, see Kpedekpo, 1982, p. 104-105.

* the number of survivors to an exact age from an assumed number of births (l_x);
* the number of years lived collectively by the survivors in a given age interval (L_x);
* total future years lived (T_x);
* the life expectancy (e_x);
* the age specific survival ratio (P_x); and
* the life table survival rate (p_x).

Although the Zimbabwean life tables do not show all of these variables, it is still useful to discuss them as each variable is related to the others and as some seem rather similar.

TABLE 7
MALE LIFE TABLE, ZIMBABWE, 1982

AGE (x)	q_x	l_x	L_x	T_x	e_x
0	0.09290	100 000	93 274	5 569 686	55.697
1	0.01171	90 710	90 083	5 476 412	60 373
2	0.01009	89 648	89 196	5 386 329	60 083
3	0.00748	88 743	88 412	5 297 133	59 691
4	0.00376	88 080	87 914	5 208 721	59 136
5	0.01165	87 749	435 884	5 120 807	58.357
10	0.00988	86 726	431 490	4 684 923	54.020
15	0.01263	85 870	426 638	4 253 433	49.533
20	0.01577	84 786	420 585	3 826 795	45.135
25	0.02031	83 448	413 004	3 406 210	40.818
30	0.02626	81 753	403 400	2 993 206	36.613
35	0.03399	79 607	391 267	2 589 806	32.532
40	0.04327	76 900	376 183	2 198 539	28.590
45	0.05692	73 573	357 395	1 822 356	24.769
50	0.07390	69 385	334 106	1 464 961	21.114
55	0.09746	64 257	305 629	1 130 855	17.599
60	0.14726	57 994	268 622	825 226	14.230
65	0.21276	49 454	220 967	556 604	11.255
70	0.31922	38 933	163 592	335 637	8.621
75	0.45276	26 504	102 522	172 045	6.491
80	0.63175	14 504	49 614	69 523	4.793
85 & over	1.00000	5 341	19 909	19 909	3 728

Source: CSO, 1985, p. 178

The first thing to note is that there is a difference between the age specific mortality rate (m_x) and the probability of dying or the life table death rate (q_x). The former is the rate as outlined in paragraph 4.1. above and is determined by relating the number of deaths in a year to the mid-year population. The latter expresses the chance that an individual, who is about to enter a certain age group, will not live through that age group. In other words: m_x relates the number of deaths to the persons <u>living within</u> each age group, while q_x relates the same number of deaths to the persons who, within a particular period, will <u>enter</u> that age group (Baldwin, 1975, p. 48).

TABLE 8
FEMALE LIFE TABLE, ZIMBABWE, 1982

AGE (x)	q_x	l_x	L_x	T_x	e_x
0	0.07290	100 000	94 722	5 906 272	59.063
1	0.00981	92 710	92 173	5 811 155	62.681
2	0.00829	91 801	91 420	5 719 377	62.302
3	0.00578	91 040	90 777	5 627 957	61.819
4	0.00211	90 514	90 419	5 537 180	61.175
5	0.01005	90 323	449 080	5 446 761	60.303
10	0.00911	89 415	445 041	4 997 681	55.893
15	0.01119	88 6011	440 527	4 552 640	51.384
20	0.01394	87 610	434 995	4 112 113	46.937
25	0.1759	86 388	428 143	3 677 118	42.565
30	0.02240	84 869	419 592	3 248 975	38.282
35	0.02907	82 968	408 809	2 829 383	34.102
40	0.03719	80 556	395 290	2 420 574	30.047
45	0.04906	77 560	378 288	2 025 284	26.112
50	0.06508	73 755	356 775	1 646 996	22.331
55	0.08762	68 955	329 671	1 290 221	18.711
60	0.12523	62 913	294 869	960 550	15.268
65	0.18538	55 034	249 665	665 681	12.096
70	0.28157	44 832	192 601	416 016	9.279
75	0.41074	32 209	127 970	223 415	6.936
80	0.60341	18 979	66 266	95 445	5.029
85 & over	1.00000	7 527	29 179	29 179	3.877

Source: CSO, 1985, p. 179

An example may clarify the concepts. If we look at the Zimbabwean male life table and use the age groups 1 and 2, we can easily calculate that the number of deaths between ages 1 and 2 will be 90710 − 89648 = 1062. Relating these deaths to the mid-year population (i.e. [90710+89648]/2 = 90179) gives us the age specific death rate for this age group. Thus:

$$m_{1-2} = 1062/90179 = 0.1178$$

The life table death rate is given by the number of deaths in relation to the number of persons entering a certain age group, in this case those who will reach the exact age of 1 (i.e. 90710 persons). Therefore:

$$q_{1-2} = 1062/90710 = 0.1171$$

While in this example the rates are rather similar, considerable differences may arise when the number of deaths between two age groups is high, as is the case with age group 0-1 and the groups above 50.

The age specific death rates will always be (slightly) higher than the life table death rates, as the denominator will be somewhat lower. If we are dealing with 5-year age groups the q_x will approximately be 5 times m_x (though always slightly less than that), as there are nearly five times as many people living in such an age group as entering it. Note also that in the oldest age groups (85 and over) q_x will always be exactly 1.000, as all human beings will eventually die.

The survivors to an exact age (l_x) are the number of persons who live up to a specific age in the course of a year. Thus for the Zimbabwean males in 1982 (table 7) out of 100 000 births only 90 710 babies will celebrate their first birthday, 89 648 their second etc. L_x are the number of survivors <u>within</u> a certain age group. In table 7 above, the number 93 274 denotes the number of boys between 0 and 1. This is obviously not the same as the number surviving up to one year (l_x), as some of those between 0 and 1 will still die before they reach their first birthday. Between the ages 5 and 85 one can approximate L_x by averaging the relevant l_x's (Morgan, 1969, p. 2).

For instance: $L_{15-20} = \frac{5 * (85870+84786)}{2} = 426\ 640$

This is only marginally different from the value in the table (426 638). For ages below 5 and above 85 more precise formula are required.

Two meanings can be attached to L_x. The first is that it denotes the age structure of the life table population (which is constant by definition), and therefore makes it possible to calculate the percentage of the population in each age group. The second meaning is the total number of years lived collectively between two exact ages in any one year. Thus: Zimbabwean males between 20 and 25 can expect to live in total 434 995 man years, given an initial (birth) cohort of 100 000. Or: given an annual birth cohort of 100 000 and certain age specific death rates, we expect at any one moment to have 434 995 males in between the exact ages of 20 and 25.

The total number of future years lived (T_x) is the cumulative of all the values of L_x. It can easily be calculated by cumulating backwards the values of L_x, starting from the last age group, in this case 85 years and above. Like with L_x, we can attach two meanings to T_x (Morgan, 1969, p. 4). First, T_x is the number of people at and above a certain age in the life table population. For instance: in the Zimbabwean life table population there will be 1 290 221 females of 55 years and above. Second, it indicates the total number of future person-years which will be lived by the survivors at a certain age. Or: those Zimbabwean females who become 55 years of age in any one year are expected to collectively live in future 1 290 221 years before all will have died. One should remember that the interpretations all refer to the synthetic cohort in question, i.e. the fictitious cohort of 100.000 people experiencing survival ratios as prevalent at that particular moment in time.

It is only a small step from T_x to the life expectancy (e_x). If we look at the total future years lived for the female birth cohort (T_0), we see a figure of 5 906 272. This is the total future number of years that all the 100 000 new borns will live. On average someone will therefore live

$$\frac{5\ 906\ 272}{100\ 000} = 59.063 \text{ year.}$$

This is the <u>life expectancy at birth</u> (e_0). Likewise we can calculate for each age what the life expectancy will be, by relating the total future years lived (T_x) to the number of survivors at that age (l_x). In formula:

$$e_x = \frac{T_x}{l_x} \qquad (4.2.)$$

In tables 7 and 8 we saw that the life expectancy at birth is lower than at the age of 1. This is only logical as relatively many children die before their first birthday. Those that survive up till the age of 1, on the other hand, have a better chance of survival afterwards. This is reflected in the increased life expectancy for ages 1 and 2.

Finally, we have to explain the differences between the age specific survival ratio (P_x) and the life table survival rate (p_x). The latter is the probability of survival from one exact age to the next exact age. It can be compared with the ordinary survival rate (see paragraph 4.1. above), but now applied to the life table population. It can therefore be calculated as $p_x = 1 - q_x$, or alternatively as formula 4.3.:

$$p_x = \frac{l_{x+1}}{l_x} \qquad (4.3.)$$

The age specific survival ratio is the survival ratio between one age group and the next and can be calculated by relating the number of persons in one age group to those of the previous age group. Or:

$$P_x = \frac{L_{x+n}}{L_x} \qquad (4.4.)$$

This indicates the proportion of people living in a certain age group that will survive to the next age group. These survival ratios are the ones that are used in population projections through the cohort survival method. The survival ratio from birth (P_b) denotes the proportion of babies to be born in the next twelve months that will still be alive in 1 year's time from now or -in the case of the model life tables in the annex- that will be alive in 5-years time. It is calculated by:

$$P_b = \frac{L_5}{l_0} \qquad (4.5.)$$

An example from the male life tables of Zimbabwe may illustrate the difference between the survival rate and the survival ratio. If we take the group of 10 years, the survival rate will be: $p_{10-15} = 1 - q_{10-15}$ which is here $1 - 0.00988 = 0.99012$, or alternatively l_{15}/l_{10}, which is $85870/86726 = 0.99013$[11]. This means that those boys who live up to the exact age of 10 will have a 99.01% probability of surviving up to the exact age of 15. The survival ratio, on the other hand, looks at those boys who are now in between 10 and 15 years old and who will be between 15 and 20 years of age in 5-years time. The chance that someone from this group will survive is $P_{10-15} = L_{15-20}/L_{10-15}$. In this particular case: $426638/431490 = 0.98876$, or there is a 98.88% chance that someone from the age group 10-15 will survive the next five years.

Difference due to rounding.

Life tables can be constructed and displayed in two ways: as a complete and as an abridged life table. A complete life table shows the mortality and survival experiences for single years of age, throughout the life span of the life table population. It is therefore extremely detailed, and laborious to construct. Planners will almost invariably deal with abridged life tables. In an abridged life table the mortality and survival measures are given for age groups, rather than for single years. The values are in general more approximate than in complete life tables, but accurate enough for most practical purposes (Kpedekpo, 1982, p. 105). Tables 7 and 8 start as complete life tables up to the age of 5 and then continue as abridged life tables.

In many countries figures are not accurate or recent enough for the construction of a practical life table. To overcome this problem one can make use of model life tables. Based on age specific mortality rates of 158 countries, the United Nations Population Division has established different sets of model life tables. These tables are based on the observed very close correlation between life table death rates for pairs of adjacent age groups (Baldwin, 1975, p. 50).

The best known and most widely used model life tables are the ones established by A. Coale and P. Demeny. Coale and Demeny made four types of tables: the West, East, North and South tables. The latter three are based on mortality patterns that considerably differed from the World average. The West tables are representative for most countries in the world. When given the choice it is always advised to use the West-tables, unless mortality patterns show unconventional characteristics.

Model life tables are presented in the annex to this paper. There are 24 columns in the tables, with separate presentations for males and females. The columns represent different mortality levels, indicated by different life expectancies at birth. The life expectancies vary from 20 to 73.9 years in 24 steps, conform the assumption that over time life expectancies tend to increase.

The exact column to choose depends on the information available about the population. If one knows the life expectancy at birth, one can take the column which comes closest. For instance the Zimbabwean male life expectancy at birth was determined as 55.7 years, which is close to level 70 in the model life tables. For females, with life expectancy at birth of 59.1 years, level 80 would be a best choice. Alternatively, one might have the age specific death rate for a specific age group. In that case one can use table I (annex) to determine which column fits best. If the figures point at a pattern which falls in between two levels, one can use interpolation to arrive at a more reliable estimate.

Model life tables can also be used as a check on the accuracy of population data. It would, for instance, be unlikely that males or females in one age group have mortality rates observed at level 40, while in the next age group the rates are like level 90.

5. POPULATION MOVEMENTS

Among the factors that influence population growth or decline in an area, migration is the most difficult one to measure and predict. Yet certainly for sub-national areas migration is often the predominant force in population dynamics. Moreover, the selective nature of migration makes it a phenomenon that requires careful attention of planners for both the area where people come from and where they arrive.

In this chapter first methods to measure or estimate migration are presented, followed by a discussion on the causes and consequences of migration. In addition, an introduction to population laws and theories is provided.

5.1. Defining and measuring migration

While there is no dispute that migration involves the movement of people over some distance and for the duration of some time, there is no agreement on the exact definition of a migrant. Some people say that a migrant is someone who changes his or her environment. But then, what constitutes the environment? A common definition, however, is that "a migrant is a mover who changed the political area of his usual residence" (Shryock, Siegel, et al., 1976, p. 373). A political area can be seen as an area within administrative boundaries. A migrant is consequently someone who crosses an administrative boundary with the purpose of taking up residence in another area than his area of origin.

Two problems emerge from these definitions. The first concerns the administrative boundaries. What boundaries does one take into account: provincial, district, ward, or village boundaries; or statistical enumeration areas; or urban constituencies? This would clearly depend on the purpose of the exercise. For district population projections for instance, the district boundary is the relevant one, as one needs to have an indication of the number of people moving in and out of the district. But if one wants to compare internal migration in one country with another, then the nature of administrative subdivisions becomes important. A large number of small administrative areas will obviously result in higher migration figures than when a country is subdivided in a few larger areas (Onokerhoraye, 1985, p. 112). The second problem is related to the duration of the move. Clearly, commuting between home and workplace or home and school does not qualify as migration. But what about a university student who moves from his home to university accommodation for an academic term? What, in that case, does constitute his `usual place of residence'? There is no universal agreement on the time-scale before calling a mover a migrant, although twelve months has been suggested as a useful cut-off point.

In defining migration and migrants a distinction has to be made between international migration and internal migration. An international migrant crosses an international border, while an internal migrant moves within the borders of his country. While international migration is usually well recorded and has received much attention from population geographers, internal migration is of more interest to sub-national planners. The following sections will therefore be largely devoted to internal migration.

Internal migrants are both in-migrants and out-migrants, depending on the view one takes, as every move is an out-migration with respect to the area of origin (departure) and an in-migration with respect to the area of destination (arrival). The United Nations (1970) define an <u>in-migrant</u> as "a person who enters a migration-defining area by crossing its boundary from some point outside the area, but within the same country". An <u>out-migrant</u> then is "a person who departs from a migration-defining area, by crossing its boundary to a point outside it, but within the same country".[12] <u>Net-migration</u> is defined as the balance between in-migration and out-migration and can be characterised as net in-migration or net out-migration, depending on the predominant flow.

Measures of migration can, like birth, death, fertility and mortality rates, be expressed per thousand of the population. The in-migration, out-migration, and net-migration rate respectively are given as:

$$\text{in-migration rate } (M_i) = I/P \tag{5.1}$$
$$\text{out-migration rate } (M_o) = O/P \tag{5.2}$$
$$\text{net-migration rate } (M_n) = \frac{I - O}{P} \tag{5.3}$$

where I is the number of in-migrants during a specific time in a certain area, O the number of out-migrants during a specific time from a certain area, and P the `population at risk'. The latter refers to the fact that the P is not necessarily the same for the three formula's. For out-migration, the population at risk, is that of the area from which out-migration takes place. For in-migration one usually takes the population of the area of arrival, while for net-migration it obviously requires the base for in- and out-migration to be similar (Shryock, Siegel et al., 1976, p. 375-376). With respect to the time interval one generally takes the mid-period population of the area in question. However, for the out-migration rate one sometimes takes the population at the beginning of the interval to determine a probability rate for migration.

There is some confusion over the term gross migration rate. In many textbooks it is defined as the number of in-migrants plus the number of out-migrants divided by the population at risk ([I+O]/P). However, following UN conventions, it seems better to refer to this measure as the <u>turnover</u> for an area, and to equate the gross migration rate either with the in-migration rate or the out-migration rate.

Related to the problem of defining migration is the difficulty in measuring it. The best source of information would be a good

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[12] In-migrants and out-migrants need to be distinguished from immigrants and emigrants. The latter terms refer to international migration.

continuous population register at local level. While for most countries in Western Europe and North America these registers exist, in Africa they are invariably absent. One therefore has to rely on two other sources: field enquiries and censuses. Specifically censuses provide a useful source of information as generally questions concerning place of birth, place of residence on a specific date before the census, and duration of residence in the place of enumeration are included. These data may be supplemented or cross-checked with sample surveys. However, as long as there is no continuous registration system, one has to rely on various estimates to determine the amount and direction of migration.

There are various methods to estimate migration rates, particularly the net migration rate. The most simple one is the balancing equation method, which makes use of the basic demographic equation:

$$\text{net migration} = P_t - P_0 - B + D \tag{5.4}$$

where P_t is the population at the end of the interval, P_0 the population at the beginning of the interval, and B and D the number of births and deaths, respectively, in the interval. Net migration is simply calculated as the residual of population growth, once births and deaths have been accounted for. This method requires knowledge of the population at two moments in time as well as of the vital statistics in the period in between. As this information for sub-national areas is absent more often than not, one generally has to rely on other methods.

A related method is the national growth rate method, which makes use of average annual growth rates and assumptions on the rate of natural increase. One generally assumes that the national rate of natural increase is equal to the total national population growth rate, the effects of emigration and immigration equalling out. A further assumption involves the rate of natural increase in the region (province, district), which is assumed the same as the national rate. If these assumptions are not too unlikely, then the following equation can be used to estimate the net migration rate:

$$M_n = \text{average annual population growth rate} - \text{RNI} \tag{5.5}$$

To give an example from the Chaminuka District Council area, Mashonaland Central province, Zimbabwe: based on the population censuses in 1969 and 1982 the average annual rate of growth for the district was 4.6%. Assuming a similar rate of natural increase in the district as for the whole of Zimbabwe (about 3.0%), the net migration rate can be calculated as:

$$M_n = 4.6\% - 3.0\% = 1.6\%$$

In other words: in the period 1969-1982 there was an average annual net in-migration of 1.6% of the population of Chaminuka district. Whether the assumption that the rates of natural increase for the area and the nation are similar is correct, is debatable. Differences in age and sex structure may cause substantial differences in the rate of natural increase over various areas.

Widely applied is also the <u>survival ratio method</u>. This method compares the actual population at a certain moment in time (census) with the expected population. The expected population is calculated on the basis of the population at a previous moment and the survival ratios (or survival rates[13]) applicable to that population. For that purpose it disaggregates the population by age and sex. For each age group and sex the formula for this method shows like:

$$M_n = P_t - sr * P_o \qquad (5.6)$$

where M_n, P_t, and P_o are defined as before, but now refer to a specific sex and age group, and sr is the survival ratio for that particular group. Table 9 illustrates the method.[14]

<u>Table 9. Estimating male net migration for the ages 10-14 to 35-39, using the survival ratio method.</u>

Age 1982	Age 1987	Population 1982	5 year survival ratio	Population 1987	Expected survivors 1987	Net Migration 1982-1987
10-14	15-19	55422	0.9888	54876	54801	+ 75
15-19	20-24	47847	0.9858	52198	47168	+5030
20-24	25-29	49937	0.9820	50673	49038	+1635
25-29	30-34	44806	0.9767	44508	43762	+ 746
30-34	35-39	31461	0.9699	30272	30514	- 242
35-39	40-44	24391	0.9614	22894	23450	- 556
Total		253864		255421	248733	+6688

This method creates some problems for the lowest age category, as it requires information of the number of new borns in between the two years. The only way to know how many children have been borne in the intercensal interval is to have a complete birth registration, but that is, as was mentioned above, often lacking.

The last method to be discussed here is the <u>place of birth method</u>. Contrary to the other methods, this method does not require any recorded vital statistics. Information can rather be collected at one moment in time and demographic analysis based on census information often makes use of this method to make

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[13] Depending on the way in which the population information is given. Usually survival ratios will be used. See also section 4.2.

[14] This table uses the forward survival projection method, as the population in 1982 was carried forward in time. However, the opposite would also be possible. This is called the reverse survival projection method and involves multiplying the population in 1987 by the reciprocal of the survival ratio. Net migration results of both methods differ, but can be averaged to find a more sophisticated measure. See also Woods, 1979, p. 168-169.

estimates of migration flows. The two basic questions to ask a respondent concern his place of birth and his place of residence at the moment of enumeration.[15] Based on these two questions one is able to make a crosstabulation of place of birth by place of enumeration. From this table the various life-time migration rates can be determined.

This method refers to life-time migration as there is no specified period over which migration is measured. One simply compares someone's place of birth with his/her place of residence, irrespective of the time when the move was made. The method also does not take intermediate migrations into account, just as it doesn't register return migrants as migrants. Other weaknesses of the method are: short distance migration (intra district or intra provincial) are not recorded, and children might be borne at other places than the actual place of residence (hospitals in another district for instance). Finally, when a census is undertaken on a <u>de facto</u> basis, some temporary visitors might be classified as life-time migrants.

Information on place of birth and place of enumeration for the eight Zimbabwean provinces is provided in table 10. Province of birth is indicated on the vertical axis, while province of enumeration -at the moment of the 1982 census- appears on the horizontal axis. The underlined numbers on the main diagonal of the table concern people who live in the province of their birth. These people are referred to as non-migrants, although they might have made several moves in their life-time.

<u>Table 10. Population by province of birth and province of enumeration, Zimbabwe, 1982</u>

Province of birth	Province of enumeration (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	Total Born
(1)	<u>899040</u>	10780	131000	17580	25110	780	27320	23220	1134830
(2)	5990	<u>496280</u>	60500	42790	4230	380	6810	2100	619080
(3)	37050	56660	<u>849240</u>	50740	13850	2140	30550	8660	1048890
(4)	5840	24890	64720	<u>561160</u>	9620	2480	31060	3650	703420
(5)	7270	5040	18130	11010	<u>589850</u>	22130	32100	5680	691210
(6)	1070	1100	18000	3200	100990	<u>494000</u>	22100	5090	645550
(7)	14360	10200	64040	41660	44830	8670	<u>820290</u>	38900	1042950
(8)	29880	14820	51000	22380	23840	2290	92080	<u>870500</u>	1106790
Other	51860	50210	79240	72980	28900	5270	16430	15560	328450
Total Enume-rated:	1052360	677980	1335870	823500	841220	538140	1078740	973360	7321170

Source: CSO, 1985, p. 60

Note: (1) - Manicaland
(2) - Mashonaland Central
(3) - Mashonaland East
(4) - Mashonaland West
(5) - Matabeleland North
(6) - Matabeleland South
(7) - Midlands
(8) - Masvingo

On the basis of this information one can calculate the number of migrants in and out of each province and the in-, out-, and net-migration rate. An example of these calculations for Manicaland province is given in table 11.

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15 In addition one often asks for the place of residence one year prior to the census date in order to determine movements over one year. The Zimbabwean 1982 census also used this question, besides the other two (CSO, 1985, p. 58).

Table 11. Calculation of migrants and migration rates, Manicaland province, Zimbabwe, 1982.

(1)	Population enumerated in Manicaland 1982	=	1052360
(2)	Population born and living in Manicaland	=	899040
(3)	Population born in Manicaland	=	1134830
(4)	Number of in-migrants [=(1)-(2)]	=	153320
(5)	Number of out-migrants [=(3)-(2)]	=	235790
(6)	Net migration [=(4)-(5)]	=	- 82470
(7)	In-migration rate [=(4)/(1) * 100]	=	14.6%
(8)	Out-migration rate [=(5)/(3) * 100]	=	20.8%
(9)	Net-migration rate [=(6)/(1) * 100]	=	- 7.8%
(10)	Turnover rate [=(4)+(5)/(1) * 100]	=	37.0%

Source: Data taken from CSO, 1985, p. 62; calculations based on Shryock, Siegel et al., 1979, p. 387.

In line with the principles outlined earlier concerning the calculation of migration rates, the `population at risk' is not the same in all of the cases. For the determination of the out-migration rate the number of out-migrants has been divided by the population born in Manicaland, while for the other rates the population enumerated in Manicaland is taken.

The methods above are the main ones in measuring migration. Other methods exist, just like variations to these methods. For a useful review see Shryock, Siegel et al. (1979, chapter 21).

5.2. Causes and consequences of migration

Despite the fact that there are many forms and types of migration (including rural-urban, rural-rural, urban-urban, urban-rural, circular, step-wise etc.), the underlying reasons for people to move can generally be grasped in a push-pull framework of analysis. The basic axiom is that a human being is inclined to stay in the same community or area as long as he or she can live there in a satisfactory manner. Only when the level of satisfaction will be reduced to an unacceptable level for a prolonged time, will he or she tend to leave. There are always costs involved in moving, whether of an economic or psychological nature, and people will only move when the expected rewards more than offset these costs.

For both the area of departure and the area of destination `push' and `pull' factors are at work. An individual will only then move when his estimation of the net effect of these factors is positive towards the area of destination. `Push' factors in the African setting include landlessness, poverty, cultural alienation, persecution, lack of amenities and services (health, education, safe water etc.), hunger, war, natural disasters like drought etc. `Pull' factors, on the other hand, are associated with safety, job and income opportunities, amenities of various kinds, availability of land, housing etc.

The decision to migrate should not be confused with the decision to select a destination, although the two are closely related (Kosinski and Prothero, 1975). For an individual to choose a destination he or she needs to have information about that location. This information will be weighted against information about other potential destinations. The process of weighing is dependent on the quality and amount of information, but also on the perception of the potential migrant. The perception in turn, is influenced by individual, cultural and environmental characteristics of the potential migrant and his/her community.

Although `push' and `pull' factors can be seen as the direct motives for migration, they themselves are caused by underlying social, economic and demographic situations and processes in areas of origin and destination. Landlessness in rural Zimbabwe, for instance, may be caused by many factors among which the colonial history and policies towards land and agriculture, as well as population growth in comparison to available natural resources, predominate. Rural-urban migration, in general, is related to processes of agricultural commercialisation, industrialisation, construction of transport links etc.

However, migration is not only dependent on societal processes and structures, it also creates new structures and processes in areas of origin and destination. The massive absence of able-bodied men in Lesotho, for instance, working in the South African mines, has created an agricultural system, which is largely run by women, children, and elderly men, with all kinds of implications for decisions on investments, for agricultural productivity, but also for the need for further labour migration. At the same time the migrant's exposure to different life styles has induced an imitative consumption pattern, with respect to food, clothing, electrical appliances etc., which has a significant impact on the sending community in a social way (van der Wiel, 1977, p. 93-96; ILO, 1979, p. 61-64).

The selective nature of migration has often been stressed. Selectivity means that various characteristics of migrants differ from those of non-migrants.[16] Among those characteristics age, sex, culture, education, and income feature in many studies. However, also psychological characteristics, like innovativeness, and attitudes towards risk, have been noted as differential attributes. Many types of migration are age related: movements to school, university or college; marriage; retirement etc. Others feature mainly among one of the sexes, as in the case of labour migration. In general people with a higher educational level tend to be more migratory than those with only a few years of schooling.

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[16] Selectivity is dependent on type and cause of migration. Migrants fleeing for war or natural disasters, for instance, are selective in other ways than those migrating in search of a job.

Due to the selective nature of migration, it can have significant consequences for both area of origin and area of destination. This again depends on the type of migration and the characteristics of the areas involved. Here we will focus on rural-urban migration, as it is the dominant form of migration in sub-Saharan Africa at the moment. A general pattern, although far from exclusive, is that young males are dominant among the migrants. These males move to towns looking for work, which might be temporary (for instance in the slack agricultural season), but if they succeed and also find suitable accommodation wife, children and eventually other family may follow. Family and friends in town tend to play an important role in channelling information to potential migrants, and in assisting them in the first few weeks after arrival in towns.

For the rural areas of origin, rural-urban migration generally means the loss of manpower. If this loss is significant it might lead to labour shortages, particularly during peak periods in the agricultural season, although this is sometimes lessened when migrants temporary return for ploughing or harvesting. Another economic consequence is sometimes that labour market chances for those remaining increase, and that wages may rise (Gaude and Peek, 1976). In cases where part of the family remains in the rural area remittances are often send, which generally means that the inflow of money into the area is larger than it would have been the case without migration. The form in which the remittances are send (cash or goods, like fertiliser, cattle, or consumption goods), and the way in which the money is used (investment or consumption, rural or urban goods) further determine whether this will contribute positively to the development of the rural areas. Besides economic consequences, migration also has social repercussions. The community may loose its cohesion; it may also loose its ability to make decisions, when many heads of households and income earners are away, thus creating a society dependent on external actions. Finally, prolonged absence of one of the partners, usually the male, may result in marriage problems.

For the urban destination areas rural-urban migration may also have a number of effects. A first consequence may be pressure on the labour market due to the influx of job-seeking migrants. This may result in continuous low wages for unskilled labour and/or an expansion of the urban informal sector. Rural-urban migration will in any case cause pressure on the urban housing market and on other urban services. On the other hand it may also have beneficial economic effects in the sense that an increase in the number of people implies a growing demand for food, consumption goods, and services. It may thus help to boost the local economy, depending on the migrants' success on the labour market, their purchasing power and the amount of money spent locally.

In Zimbabwe rural-urban migrants often keep interests in their rural area of origin. This is seen as a survival mechanism, a fall-back position in times of hardship. Also, some people like to retire in the rural area of their birth. Nevertheless not all urbanites do have these linkages. Schlyter (1990) distinguishes four groups with loose rural ties in Harare: non-Zimbabweans (labour migrants, refugees), former farm or mine workers, city born people, and women whose social practices have excluded them from the rural areas.

In any case, rural-urban migration is more than the mere movement from rural to urban areas. It has several economic consequences, and builds or destroys social networks. These types of consequences are often hidden behind the `hard' figures. Nevertheless they are of major importance in understanding the dynamics of both rural and urban areas, and should therefore be of central concern to any planner.

5.3. An introduction to migration laws and theories

At the end of the 19th century the first systematic studies of migration were undertaken, and the first `laws of migration' formulated (Ravenstein, 1885 and 1889). A voluminous body of literature has appeared since, covering many aspects of migration and pointing at many regularities in migration patterns and processes. Only a very introductory review can be provided here, with a focus on regularities in internal migration. Whether these regularities can be labelled `theories' or `laws' is point of dispute which will not be dealt with here.

Lee (1966) returned to Ravenstein's laws, reformulated them in a series of hypotheses, and making them more up to date. His hypotheses refer to the volume of migration, to migration streams and counterstreams, and to the characteristics of migrants. The most important ones are:

On the volume of migration:

1. the volume of migration is related to the difficulty of surmounting intervening opportunities;
2. the volume of migration varies with fluctuations in the economy;
3. unless severe checks are imposed, both volume and rate of migration tend to increase with time.

On migration stream and counterstream:

1. migration tends to take place largely within well-defined streams;
2. for every major migration stream, a counterstream develops;
3. the efficiency of the stream (i.e. the ratio of stream to counterstream or the net redistribution of population effected by the opposite flows) is high if the major factors in the development of a migration streams were negative in the area of origin;
4. the efficiency of migration streams will be high if the intervening obstacles are great.

On the characteristics of migrants:

1. migrants responding primarily to positive factors in areas of destination tend to be positively selective;
2. migrants responding primarily to negative factors in the area of origin tend to be negatively selective;
3. the degree of positive selection increases with the difficulty of the intervening obstacles;
4. the heightened propensity to migrate at certain stages of the life cycle is important in the selection of migrants;

5. the characteristics of migrants tend to be intermediate between the characteristics of the population in the area of origin and the population in the area of destination.

The formulation of these hypotheses have contributed a great deal in making the study of migration more systematic and analytic.

The relationship between migration volume, migration distance and intervening opportunities and/or obstacles has achieved a lot of attention from population geographers (see for instance Woods, 1979, p. 172-183). The basic premise is that migration volume is inversely related to distance. The exact form of the distance decay function depends on the situation at hand, but will seldomly be a straight line. To fit a regression line it therefore requires some form of transformation (see Taylor, 1975). Migration volume is obviously dependent on the number of potential migrants in the area of origin and the capacity to absorb these migrants in the area of destination. Both variables are sometimes approached through the size (population) of the areas. In conjunction with the inverse distance function, gravity models have thus been devised to make estimations of migration volume.

As noted in Lee's hypotheses above, migration is influenced by intervening obstacles between the areas of origin and destination. These obstacles may be of a political (borders, permission), economic (costs of movement), or physical (sea, mountains) nature. However, not only obstacles are seen as influencing migration, opportunities are also important. Migration is thought to be directly related to the number of opportunities in the area or destination, but inversely related to the number of intervening opportunities. In other words: if there are comparatively many (job, income, living, retirement) opportunities in between two areas, the resulting migration stream between these two areas will be relatively small, as many migrants will make use of the intervening opportunities (Stouffer, 1960).

The massive rural-urban migration in developing countries has attracted many scholars. Mabogunje (1970) analyses this form of migration within the framework of the General Systems Theory. He first sees migration as influenced by the economic, political, social and technological environment. Potential migrants receive stimuli from this environment to which they may or may not react with a decision to migrate. Two control sub-systems also play a role in the migration process: the rural and the urban control sub-system. The former refers to institutions like family, the village community etc. and influences the decision to stay (and adjust) or to move. Once the migrant has moved to town he or she will be influenced by the urban control sub-system (housing, job opportunities) and the migrant may adjust to the urban situation and become a true urbanite. Information flows play an important role in Mabogunje's systems approach. These flows provide constant feedback to other potential migrants and influence the volume and direction of subsequent migration.

Another influential contribution to the study of rural-urban migration was made by Todaro (1969, 1976, 1989). Todaro was particularly struck by the continuing massive rural-urban migration in view of rising urban unemployment rate. Following Mabogunje's systems approach one would expect negative feedbacks to rural areas, while economists argue that due to the immense migration volume -and hence large increase in supply of labour- urban wages will have to drop. In any case a general expectation would be that rural-urban migration would dwindle when urban unemployment is high. However, empirical evidence does not support this view and Todaro deserves credit for trying to explain this phenomenon. His model[17] starts from the assumption that a migration decision is a rational decision, based on economic criteria. The economic variables of interest are: (i) the difference between the rural and the urban wage rate (ii) the urban job opportunities, and (iii) the urban unemployment rate. In addition, Todaro views the migrant's perception about his chances to secure an urban income as crucial. The decision to migrate therefore depends on expected rather than actual future earnings and thus on the combination of perceived job opportunities and rural-urban wage differentials. Although chances of securing an urban job are inversely related to the urban employment rate, the decision to migrate in situations of high unemployment rates might still be rational as long as the migrant expects his urban income over a specified period to be higher than the rural alternative.

Todaro's model has faced severe criticism, particularly concerning the fact that the model sees people as either rural or urban. Some may move temporary to cities during the slack agricultural season in search for a job, but may return if the search was unsuccessful. Another criticism relates to the economic motives of migrants; other motives may as well play an important role, for instance the better urban social services. A third point refers to the fact that the model assumes a migrant to look for a job in the formal sector, while in reality many end up in informal activities. Finally, Jamal and Weeks (1988) did an empirical test on the model. They examined rural-urban income differentials in a number of African countries in the 1970s and early 1980s and concluded that the income gap between urban wage earners and the rural population has narrowed considerably. Despite this fact, migration from rural to urban areas has not abated. Jamal and Weeks conclude that migration can not be explained by the somewhat simplistic Todaro model, but that "it has to be seen as part of a much more complex and dynamic struggle to survive in the face of falling real incomes for the poor, both urban and rural" (p. 274). Besides the point, mentioned above, that people are not either rural or urban -in fact the "double status' seems to be more rule than exception nowadays-, Jamal and Weeks also pointed at the false premise that the individual rather than the family was the main decision-making body in migration. They argue that one should not look at average incomes, but " at marginal incomes - the net addition to

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17 The model is generally referred to as the `Todaro model', although some call it the `Harris-Todaro model', after the more complete formulation by both authors in 1970. Later Harris and Sabot (1982) again extended the model and made it more general.

family income from the adult son working in town versus his working on the farm" (p. 290).

Based on the observation that migration patterns evolve over time and are historical phenomena, Zelinsky (1971) proposed a theory of mobility transition. Zelinsky postulated that mobility has to be seen as parallel to socio-economic and demographic transition processes. Each phase of the modernisation process was in his view characterised by specific forms of mobility and migration. These relationships are summarised in table 12.

Table 12. Relationships between socio-economic, demographic and mobility transitions after Zelinsky (1971).

Socio-economic (modernisation) status	Demographic transition phase	Mobility transition phase
Pre-industrial (traditional)	phase I: high BR, high DR	phase I: very little mobility
Early transitional (initial diffusion of modernisation)	phase II: high BR, falling DR	phase II: start of rural exodus: E, and RU massive
Late transitional (extensive diffusion of modernisation)	phase III: decrease in BR and DR	Phase III: RU important but decreasing, decrease in E, start of UU
Advanced industrial (modern)	phase IV: low BR and DR, low NI	phase IV: RU insignificant UU increasing, just like C
Post-industrial (neo-modern; socio-cultural convergence)	phase V: low BR and DR no or controlled NI	phase V: only UU and C

Notes:
1. demographic transition phases: BR = Birth Rate; DR = Death Rate; NI = Natural Increase
2. mobility transition: RU = Rural-Urban migration; UU = Inter/Intra-Urban migration; E = Emigration; C = Circulation (reciprocal movements)

Source: adapted from Kosinski and Prothero (1975)

Like modernisation theory in general and the demographic transition theory Zelinsky's mobility theory can be criticised on its preoccupation with patterns, rather than the fundamental causes for these patterns. More seriously, it does not recognise the fundamental differences between the history of the now developed countries and the developing countries. Finally, it has an implicit conviction in a unilateral type of progress in all countries of the world, be it at different moments in time. Nevertheless it will be interesting to observe future developments in migration in view of this theory.

6. POPULATION COMPOSITION

Planners are not only interested in the dynamics of the population in a certain area, but also of its structure at a particular moment in time. The population structure or composition is the result of developments in the past and is -of course- subject to constant changes.

The composition of a population refers to any characteristic according to which that population can be subdivided, whether it is sex, age, marital status, education standard, religion, nationality, economic position etc.. In population studies generally two stand out: age and sex characteristics. They will also be the main focus of this chapter.

Information about the structure of the population can be used for various planning purposes. Data about age and sex can be used in social services planning, and in labour force forecasts; combined with income data they can be applied in market studies; and information on economic positions is an input into labour market prospects.

6.1. Age composition and dependency ratio's

Age is an important variable as many tasks and roles in society change with age, as well as individual characteristics, aptitudes and attitudes. One only has to think of education, employment, reproduction, physical and mental abilities to appreciate the importance of the age distribution of the population of a particular area.

In representing age the term `cohort' is often used. A cohort is a group of persons born in the same period. A birth cohort, for instance, is a group of people born in the same calendar year. For many applications, like population projections, people are grouped into 5-year cohorts, i.e. groups of people born in the same 5-year period. This does not necessarily refer to calendar years, it might also be measured backdating from the moment of a census.

Another generally applied age subdivision is broader and makes a distinction in three age groups: 0-15 years; 15-65 years; and 65 years and above. This subdivision is the basis for labelling a population as `young' or `aging', as well as for the calculation of the age dependency ratio.

According to Baldwin (1975) areas are said to have a young population when more than 40% of the population is under 15 years of age, while less than 5% is above 65. On the other hand, when areas have less than 30% of their population under 15 and more than 10% above 65, then their populations are called `aging'. Zimbabwe, with its 49.4% under 15 and 3.9% above 65, clearly has a young population. There are however differences between provinces and even more so between various areas within a province, as table 13 shows for Matabeleland North.

Table 13. Age distribution by type of administrative area, Matabeleland North, 1982.

Area	Age distribution		
	0-15	15-65	65+
District Council Areas	52.7%	43.4%	3.7%
Rural Council Areas	45.8%	50.8%	3.1%
Main Urban Areas	35.0%	62.8%	1.8%
Total Province	42.2%	55.0%	2,6%

Source: CSO, 1989b, p. 10.

The age dependency ratio looks at the number of people in the groups 0-15 and 65+ relative to the ones in the 15-65 group and is defined as:

$$\frac{\text{Population 0-15} + \text{Population 65+}}{\text{Population 15-65}} \times 100 \qquad (6.1)$$

Like the labels 'young' and 'aging' above, it is an indicator of the age composition of a population. It also differs significantly per areal unit, as table 14 shows.

Table 14. Dependency ratio for various districts, Matabeleland North, 1982.

Area	Dependency Ratio
Binga District Council	130.6
Hlangabedzi District Council	113.7
Kusile District Council	139.7
Nkayi District Council	133.0
Tsholotsho District Council	130.3
Hwange District Council	118.1
Bubi Rural Council	103.5
Gwaai Valley Rural Council	76.3
Nyamandlovu Rural Council	104.8
Bulawayo	58.1
Hwange	65.3
Victoria Falls	64.4
Total Province	81.4

Source: CSO, 1989b.

Although one generally assumes people in the 15-65 age group to be economically active and those in the other age groups to be inactive, and therefore the age dependency ratio to reflect an economic dependency ratio, this is not correct. Many people below the age of 15 and above 65 are economically active, certainly in the African context. In addition, not all people in the 15-65 age category are actually working or even capable or willing to work (students, housewives, disabled, unemployed etc.).

If one wants to have an indication of economic dependency, or the load in terms of numbers of dependents that the active population has to carry, it is better to use the <u>economic dependency ratio</u>. This is defined as:

$$\frac{\text{non-workers}}{\text{worker}} \times 100 \quad \text{or:} \quad \frac{\text{inactive population}}{\text{active population}} \times 100 \qquad (6.2)$$

A variation to this ratio is the <u>activity rate</u>. An activity rate is the economic active proportion of a given group of persons. It can be defined as:

$$\frac{\text{economically active population}}{\text{total population}} \times 100 \qquad (6.3)$$

The population may refer to the total population of an area or to a certain age and/or sex group. Activity rates vary over countries and regions as well as over sexes, depending on factors like average level of income, type of job opportunities available, health situation of the population, religion and custom (Onokerhoraye, 1985, p. 148-150). Activity rates by sex for the various administrative areas of Matabeleland North are presented in table 15[18]. Here only the population above 15 years of age has been considered.

<u>Table 15. Activity rates by sex and type of administrative area, Matabeleland North, 1982.</u>

Area	Males	Females
District Council Areas	72.6%	41.6%
Rural Council Areas	82.2%	38.4%
Main Urban Areas	81.7%	40.1%
Total Province	79.4%	40.4%

Source: CSO, 1989c, p. 9.

Another age dependency measure one sometimes encounters is the <u>child dependency ratio</u>. This can be defined as:

$$\frac{\text{Population 0-15}}{\text{Population 15-65}} \times 100 \qquad (6.4)$$

This measure gives an indication of the education burden society has to bear. If the child dependency ratio is [illegible] over time it reflects the various demographic developments of a population. Declining infant mortality would, for instance, be reflected in an increase in the dependency ratio.

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18 To be completely accurate: these are labour force participation rates. The difference with activity rates is based on the reference period over which one measures someone being active or not. This is further discussed in paragraph 6.3

6.2. Sex ratio's

Any human population is composed of two sexes only: males and females. The main measure to indicate the numeric relationship between both sexes is the sex ratio. This ratio is the number of males per 100 females, or:

$$\frac{P_m}{P_f} \times 100 \qquad (6.5)$$

where P_m stands for the number of males and P_f the number of females. A sex ratio above 100 indicates an overrepresentation of males, while the reverse is true for a sex ratio below 100. In the Zimbabwean census of 1982 there were 3673620 males and 3827850 females, thus the sex ratio was:

$$\frac{3673620}{3827850} \times 100 = 95.97 \text{ or } 96.0$$

This indicates an overrepresentation of females. For non-citizens, on the other hand, the sex ratio was 132.8, which indicates a substantial outnumbering of females by males. This exceptional number might have been caused by labour migration by males to Zimbabwe in previous decades.

Table 16. Sex ratio by administrative area, Matabeleland North, 1982.

Area	Sex Ratio
Binga District Council	80.7
Hlangabedzi District Council	99.9
Kusile District Council	93.7
Nkayi District Council	89.5
Tsholotsho District Council	84.4
Hwange District Council	91.3
Bubi Rural Council	105.9
Gwaai valley Rural Council	118.5
Nyamandlovu Rural Council	104.2
Bulawayo	112.2
Hwange	130.2
Victoria Falls	118.3
Total Province	103.6

Source: CSO, 1989c.

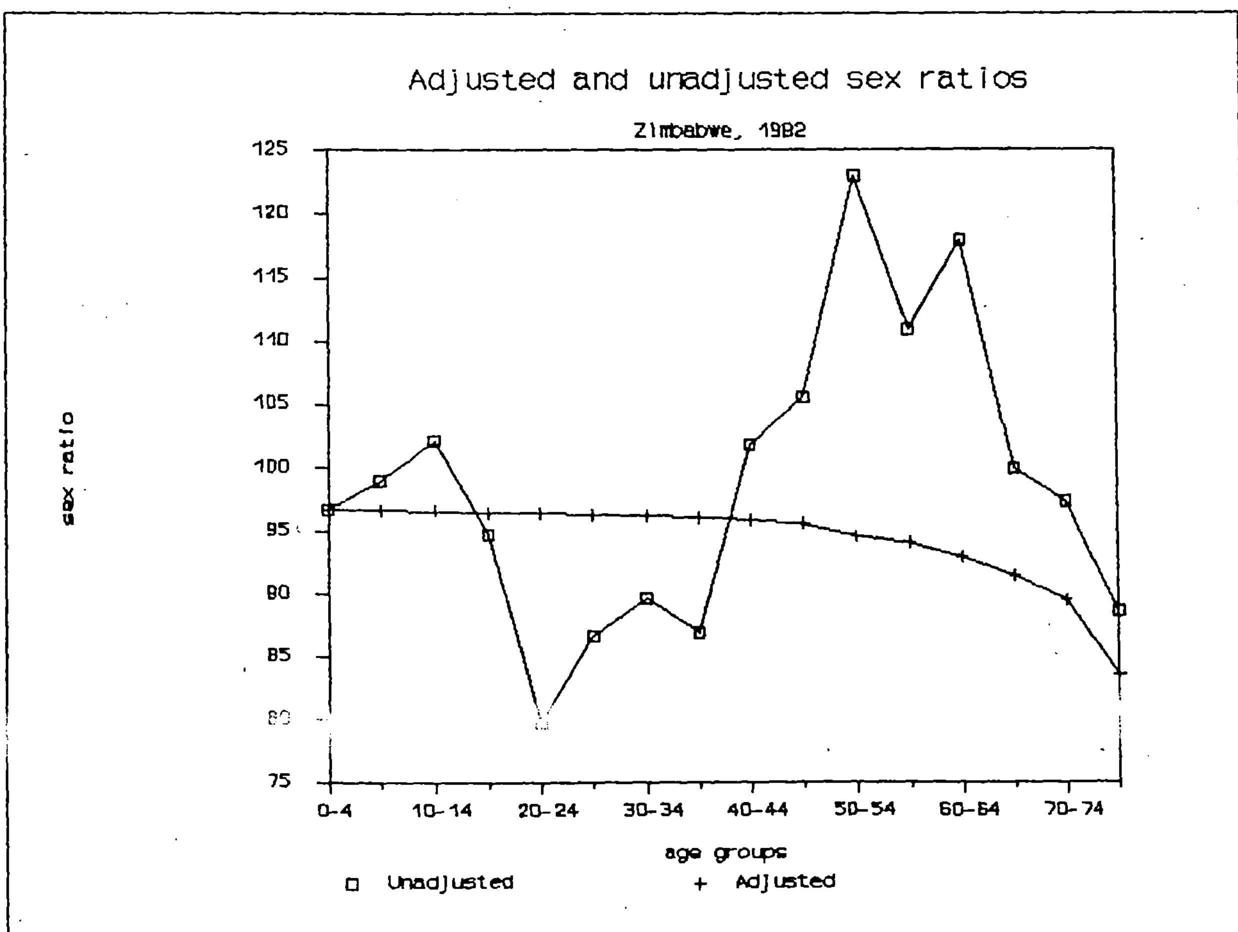
Sex ratios for nations are normally somewhere between 95 and 105, but of course there are exceptions. The 1976 population census in Lesotho for instance gave a de facto sex ratio of 75.6[19] (ILO, 1979). For sub-national areas the sex ratio may differ tremendously. As males are the most mobile group in most

[19] The de jure sex ratio was higher, but still relatively low: 93.2.

societies and tend to migrate more than women to areas of work, towns, cities, but also major mining and farming areas generally have higher sex ratios than rural areas on average. This is also evidenced in Zimbabwe, where there is a pronounced difference between district council, rural council and urban areas with respect to sex ratio. Table 16 presents details for Matabeleland North.

Sex ratios also vary over the different age groups. Normally there are more boys born than girls and the sex ratio at birth is in most countries constant at about 105 (Pressat, 1978, p. 13). However, in every age group mortality is greater among males than among females, resulting in the sex ratio to drop gradually when age increases. It appears from the 1982 census and from other sources that in Zimbabwe the sex ratio at birth is lower than 100 (CSO, 1985, p. 18-19). It seems therefore that in Zimbabwe more girls are born than boys. The CSO explains this figure firstly by referring to other African countries where the same pattern has been observed, and secondly by pointing at the large families in Zimbabwe and noting that as more children are born to a woman the chances for girls to be born seem to increase.

Figure 3



Source: CSO, 1985, p. 24

The sex ratios by age in Zimbabwe, as recorded on the basis of a 10% census sample, gave rather unexpected results: fluctuations in sex ratio as well as some fairly high ratios in the ages 45-65. Demographers do have techniques to smooth these data and to adjust them to a more universal and expected trend. Figure 3 shows both the unadjusted and the adjusted sex ratios for Zimbabwe. The adjusted trend line still differs from those in many other countries where the sex ratio starts around 105 at birth, then declines and drops under 100 around the age of 40 in western countries and around the age of 15 in developing countries.

6.3. Population pyramids

The age and sex composition of a population is often represented in diagram which is called the `population pyramid'. A population pyramid has the ages of the population on the vertical axis. The horizontal axis shows either the numbers of people in each age group or the percentage of the population in each group. In the former case one deals with an absolute pyramid, while in the latter a relative pyramid is observed. The indications on the horizontal axis may thus differ, but the form is in both cases exactly the same. By convention males are presented on the left side of the pyramid and females on the right. Detailed pyramids display one-year age groups, but often this level of detail is missing and 5- or even 10-year age groups are used. Figure 4 presents Zimbabwe's population pyramid for 1982, based on 5-year cohorts. Note that the oldest age group refers to `75 and above'; this group has to be spread out over more than 5 years. The (arbitrary) rule is to distribute this population evenly over an age range in such a way that only a few people are excluded (Pressat, 1978, p. 10). In the Zimbabwean case the 47310 males and 53440 females of 75+ have been distributed over 15 years. These figures have therefore been divided by 3 to take the spread over 15 -instead of 5- years into account.

Population pyramids facilitate the analysis of the demographic history of a population. Certain cohorts might have been particularly at risk during a war or epidemic. A rise or fall in the birth rate produces larger or smaller cohorts. Labour migration to towns may result in overrepresentations of males in several age groups. All these and other demographic phenomena are reflected in population pyramids. Moreover, due to its graphical presentation a pyramid is easier to interpret than if the data were presented in a statistical table.

FIGURE 4 AGE-SEX PYRAMID FOR ZIMBABWE 1982 Census

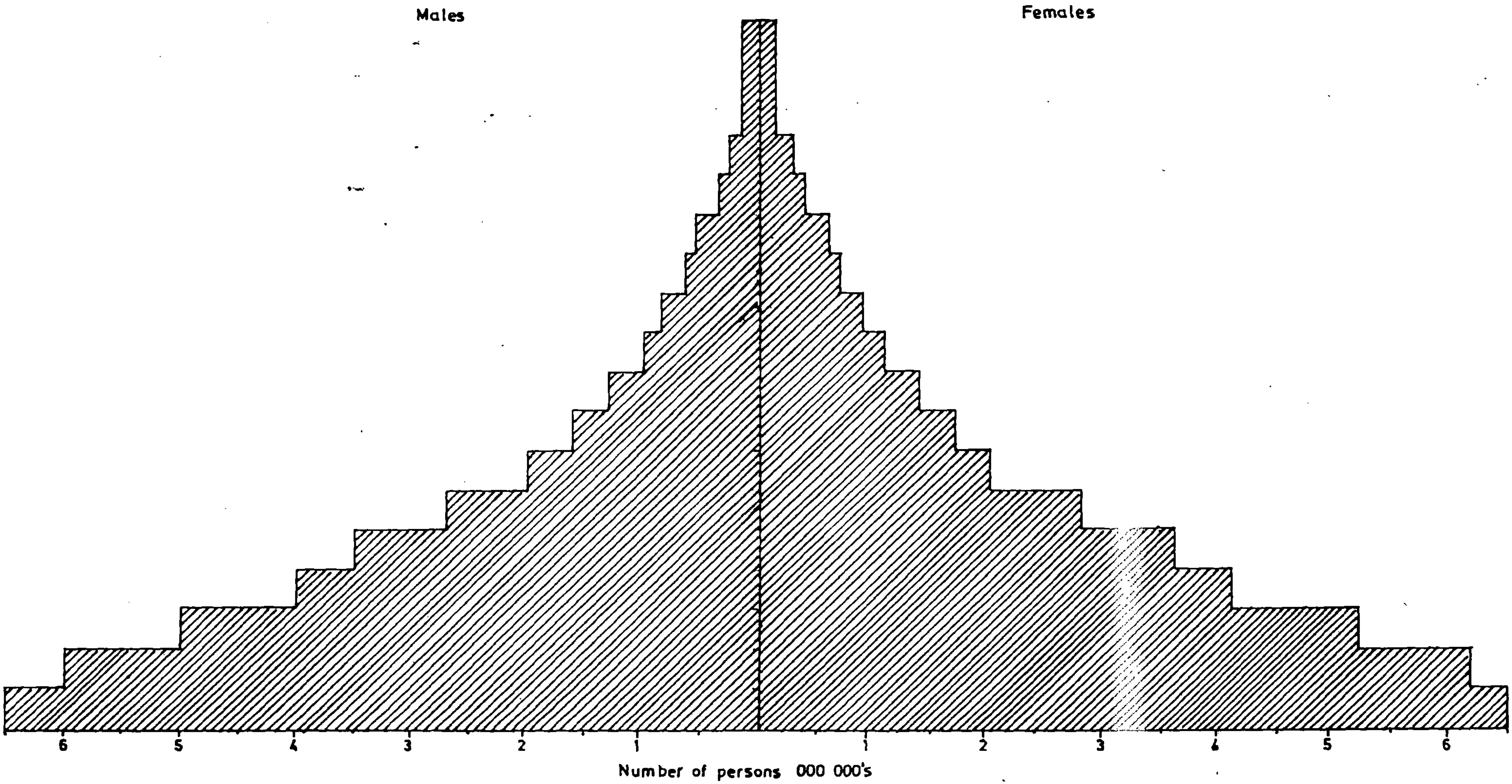
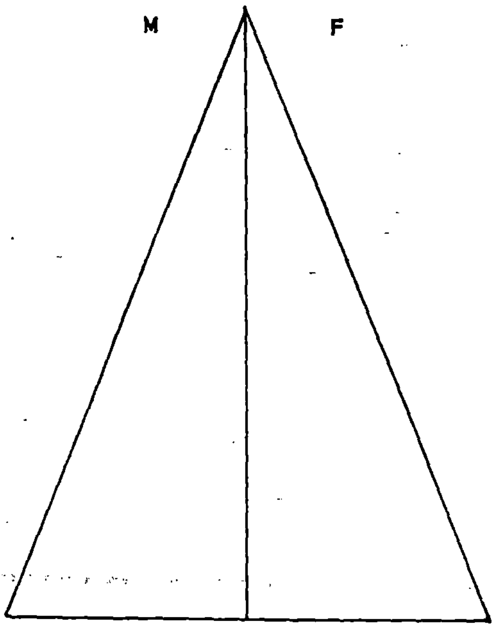
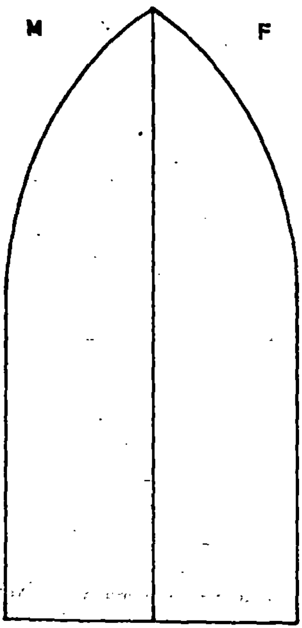


FIGURE 5 <u>General shapes</u>

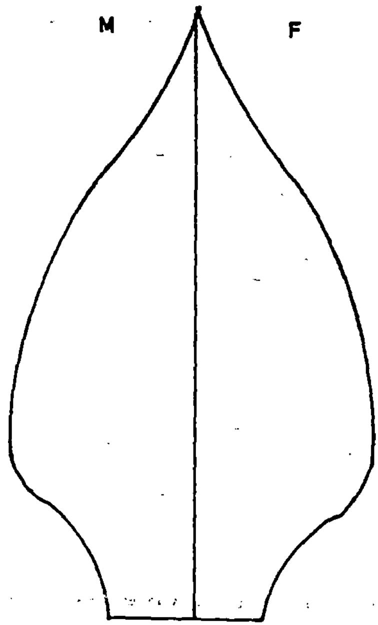


(a) 'pyramid proper'

of population pyramids



(b) 'bullet'



(c) 'onion'

The general shape of a pyramid tells us something about the growth characteristics of the population it represents. Roughly, three general shapes can be distinguished: `the pyramid proper', `the bullet form' and `the onion' (see figure 5). A real pyramid has a broad appearance at the base, caused by high birth rates. The population is consequently very young and growing rapidly. Where in addition death rates are very high, only a tiny proportion of the population will succeed in reaching the top ages. The pyramid will consequently not reach as high as when death rates were lower. The second case (`bullet form') points at a rather stable population where a new birth cohort is more or less annually replacing the deceased. Finally, the `onion' refers to a population where birth rates have dropped and where the population is likely to decline in numbers, at least in the short to medium term.

6.4. Some other composing elements

Any population is composed of and can be subdivided in many other aspects, like social status, income level, religion, educational level attained, type of job, language etc. Only the most important ones for planning purposes will be dealt with here, viz. household size, employment aspects and education.

The smallest social units in a community are families and households. The two are not identical, as families are based on marriage and kinship relations, while households are social groups living together (Onokerhoraye, 1985, p. 142). A household is usually defined as `an individual or a group of persons who make common provisions for food and other essentials of living and live on the same home-site'. Planners are generally more concerned with households than with families. Information about household size and composition is for instance used for an assessment of housing needs, for planning of various services (e.g. water and sanitation), and for various aspects of rural planning (food and nutrition studies, agricultural labour availability, rural social differentiation etc.).

Both household size and composition are dependent on social, cultural and economic factors. In Africa, where extended family ties are common, households tend to be more extended as a nuclear family (father, mother children) may also provide lodging for other relatives. Household size is measured by both the average household size and the median household size. The first is simply the average number of household members per household. While this is a useful indicator, it does not tell whether there is much variability in household size, i.e. whether there are many households that have more (or less) than the average number of household members. The median household size is obtained when half of the number of households have less and half have more members than the median figure (CSO, 1989c, p. 21-22). In conjunction some conclusions can be drawn on the variability of household size, but for a good overview more data about the distribution by size are needed. Table 17 provides this distribution as well as the average and median household size for Matabeleland North. In this province urban households tend to be smaller than rural ones, while there is also a difference between rural and district council areas, the latter having the larger average sizes. This pattern is common for the whole of Zimbabwe. Remarkable is also that about one quarter of the urban households is composed of one-person households; a striking difference with district council areas where only seven percent of the households concern people living alone.

Table 17. Average, median and distribution of household size by type of administrative area, Matabeleland North, 1982.

	District Council Areas	Rural Council Areas	Urban Areas	Total Province
Average number of hh members	5.8	4.8	4.1	4.6
Size of median household	4.83	3.62	2.65	3.30
% distribution by no. of members:				
1	7.1%	19.8%	24.9%	19.7%
2	8.7%	12.4%	16.4%	13.9%
3	11.4%	10.9%	13.4%	12.7%
4	12.5%	11.1%	12.3%	12.2%
5	12.5%	10.3%	9.8%	10.6%
6	11.4%	8.8%	7.3%	8.6%
7	9.8%	7.0%	5.3%	6.7%
8	7.6%	5.7%	3.7%	4.9%
9	5.8%	4.2%	2.5%	3.6%
10	5.7%	4.2%	1.9%	3.1%
10+	7.5%	5.7%	2.5%	4.1%

Source: CSO, 1989c, p. 13

Some comments on the economic active population and on activity rates have been made in paragraph 6.1 above. There is, however, a difference between the economically active population and the labour force, based on the reference period over which one defines `activity' or `labour'. The `usually active population' measured in relation to a long period, such as a year, is termed the economically active population. The `currently active population' measured in relation to a short reference period is called the labour force (CSO, 1985, p. 98). As the Zimbabwean 1982 census based its employment figures on `did this person work last week?' the latter of the two measures applies. In the Zimbabwean census some further information was obtained with respect to unemployment, communal farming, and type of occupation. For an extensive overview see CSO, 1985, p. 97-130.

Information about activity, labour force and type of job is used for various economic and social planning purposes. It provides insight in labour market developments, which is an important input in policy making with respect to education (appropriate curricula and types of school), minimum wage legislation, investment incentives etc. It may also point at the need for social programmes or more labour intensive activities.

Finally, some attention needs to be given to education. Education is important as it influences people's chances on the labour market as well as various attitudes to life. On employment prospects in Zimbabwe it has been observed that:

> "The inability to find work is affected by level of education. Young persons with higher educational attainment found it easier to enter employment and in general those who had secondary and higher education were more likely to be employed" (CSO, 1985, p. 130).

Literacy and education also influence demographic features as fertility and mortality. Literacy and education are positively associated with the use of family planning methods (CSO, 1986, p. 5). The 1982 census showed that the average number of children ever born (CEB) to women of 15-49 years in Harare was 3.6 for those who had no education, 2.8 for those who had up to primary education and 1.2 for women who had at least finished secondary education. In addition, rural-urban differentials exist, which is illustrated by the fact that the mean number of CEB for Harare was 2.38 for women 15-49 years of age, while for Zimbabwe as a whole it was 3.08.

These kind of considerations need to be taken into account when one is engaged in population projections. Following the observations on Zimbabwe above, one can expect the level of fertility to drop, when there is a trend towards higher educational achievements for women in the country.

7. POPULATION DISTRIBUTION

The distribution of population, on an international, national and regional scale, is influenced by a number of factors. Predominant factors are: physical aspects, like temperature, relief and moisture, and economic/technological aspects. The latter refers to the major type of economy (agrarian, industrial, post-industrial) and technical achievements in terms of production, transport and distribution. In some countries, like Zimbabwe, also historical and legislative aspects play an important role. These aspects influence the manner in which population is distributed among and within provinces, as well as between rural and urban areas.

In this chapter measures of population distribution and concentration are presented. In addition, the for planners important concept of carrying capacity is dealt with.

7.1. Measures of distribution and concentration

While populations are usually not evenly spread over space, it is nevertheless commonplace to measure population distribution through the use of average densities. Population density is an expression of the ratio between population size and size of a certain land unit or other unit of space. Several measures of population density exist, of which the <u>crude population density</u> is best known. The crude population density refers to the ratio of the number of people to the total land surface area. In 1982 Zimbabwe had a total population of 7 546 071 on a land area of 390 759 square kilometres (km^2). Hence the crude population density for Zimbabwe was 19.3 persons per km^2. This, of course, is an average figure, which conceals huge variations among provinces, districts, rural and urban areas. The average population densities for the different types of administrative units in Zimbabwe are presented in table 18.

<u>Table 18. Population densities by type of administrative unit, Zimbabwe, 1969 and 1982</u>

Administrative unit	Population density (per km^2) 1969	1982
District Council Areas	17.8	25.2
Rural Council Areas	7.3	9.4
Municipalities	442.0	870.9
Zimbabwe	13.0	19.3

Source: CSO, 1985, p. 47

For some applications the crude population density is too crude a measure and some refinement is needed. In rural areas two other density measures are usually more appropriate:

* <u>Agricultural density</u>: the ratio between the population in a certain area and the total agricultural land area. This

measure takes into account that not all rural land can be used productively. The non-productive or non-agricultural land is therefore excluded from the total land area.

* Cropping density: the ratio between the population and the total area under crops. This measure excludes land used for pasture as well as fallow land. On the other hand it counts areas used for double cropping double, as might be the case with irrigated land. It is thus a measure which indirectly relates the population to potential crop output. As it leaves livestock use out of the calculation it is recommended for cropping areas only.

In urban areas and for urban planning two other measures are often used:

* Man-dwelling density: the ratio between the population of an area and the total number of dwellings in that area. This measure tells us the average number of people per house, flat/apartment, and/or structure, depending on how one defines `dwelling'.
* Room density: the average number of people per room in a certain area. This is a variation to the man-dwelling density, and more appropriate when many rooms in an areas are (sub-)let to lodgers or other families.

While the various density measures are useful for descriptive purposes, they suffer from two disadvantages. First, all the measures are very sensitive to the level of spatial disaggregation. The average population density for Harare differs from those of the various suburbs. Obviously the Northern (low-density) suburbs have lower densities that the Southern (high-density) suburbs. An overall average conceals these variations. Second, it is difficult to exactly define and measure the denominator of each of the density measures. Should, for instance, total land area include water? And should kitchens, bathrooms etc. also be counted for the determination of room densities?

A measure that gives an indication of the spatial distribution of the population within an area is the centre of gravity. To determine the centre of gravity one gives an x- and y-value to each point in the area where people are living, as if the area was located within a pair of coordinates. Each x-point is then multiplied with the number of people living on that point, and consequently summed. The total is then divided by the total number of people to find the average x-value in the area. This is repeated for the y-values. The point which represents the average x- and y-value is the centre of gravity.

A variation to the centre of gravity is the median point of population. This median point is located in such a way in an area that, when a North-South and an East-West line cut through this point, the area is subdivided in four quarters with equal numbers of people.

The degree of concentration of population in an area can be measured by the Lorenz curve and the Gini coefficient (or coefficient of localisation). The Lorenz curve is a graphical way of depicting inequalities and was originally used to indicate concentrations of income or wealth. When applied to population concentration it plots the cumulative percentage of land (Y-axis) against the cumulative proportion of population (X-axis). to plot the actual Lorenz curve one has to take the following steps: (1) list the sub-areas of the area under study according to density, (2) calculate the cumulative of both area and population, and (3) plot the curve, starting from the sub-area with the lowest density. The curve will invariably lie in between two extremes. One extreme is the main diagonal (from below-left to upper-right) in the diagram, which indicates a completely even distribution of population among the sub-areas. In other words: if the Lorenz curve follows this diagonal all sub-areas have similar population densities. The other extreme is the curve following the X- and Y-axis. This situation occurs when all population is concentrated in one point only. The Gini coefficient measures the area between the main diagonal and the Lorenz curve and thus indicates the degree of concentration. A Gini coefficient of 0 means even distribution (curve coincides with diagonal), while a coefficient of 1 points at extreme concentration (opposite situation). The coefficient (G) is calculated by:

$$G = \frac{\frac{1}{2}\Sigma|x-y|}{100} \qquad (7.1)$$

An example for both the plotting of the Lorenz curve and the calculation of the Gini coefficient for Matabeleland North is provided in table 19 and figure 6.

Table 19. Work-table for Lorenz curve and Gini-coefficient, Matabeleland North, 1982

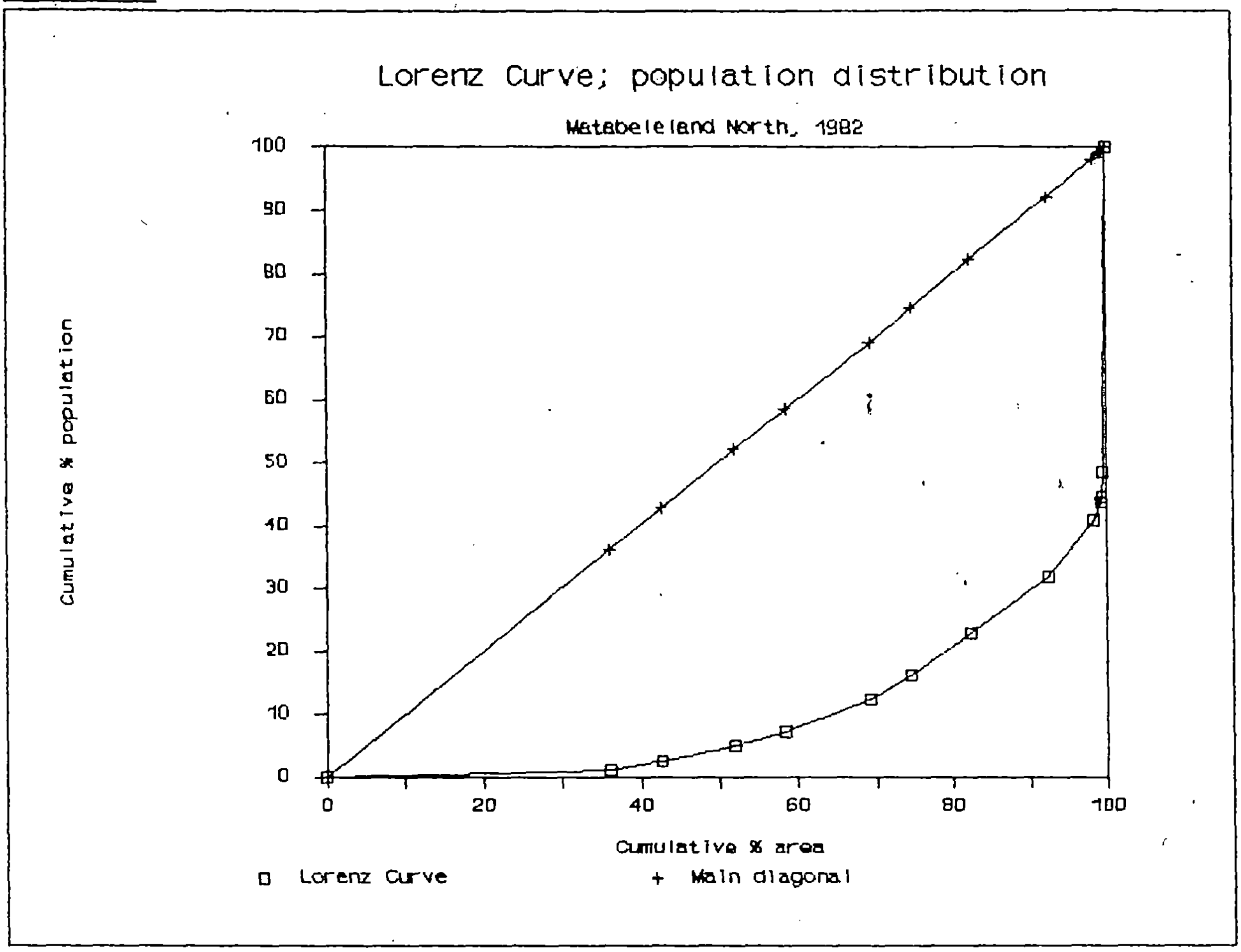
Area	Population Density	% of Pop. (x)	% of Area (y)	Absolute Difference (|x-y|)
Other areas	0.4	1.0	36.1	35.1
Gwaai Valley R.C.	3.1	1.5	6.6	5.1
Bubi R.C.	3.2	2.3	9.3	7.0
Nyamandhlovu R.C.	5.1	2.5	6.5	4.0
Binga D.C.	6.1	4.9	10.6	5.7
Hwange D.C.	9.7	4.0	5.4	1.4
Kusile D.C.	10.9	6.6	7.8	1.2
Tsholotsho D.C.	11.5	8.8	10.0	1.2
Nkayi D.C.	20.0	9.1	5.9	3.2
Bubi D.C.	37.5	2.9	1.0	1.9
Victoria Falls	116.1	0.8	0.1	0.7
Hwange	887.2	4.1	0.1	4.0
Bulawayo	1120.6	51.5	0.6	50.9
		100.0	100.0	121.4

$$G = \frac{0.5 * 121.4}{100} = 0.607$$

Source: CSO, 1989c, p. 6

The curve and the Gini coefficient show a rather unequal population distribution in Matabeleland North, caused by low densities in National Parks on the one side, and heavy population concentration in Bulawayo on the other.

Figure 6



Population distribution within Matabeleland North is much more uneven than among the eight Zimbabwean provinces. The Lorenz curve for the Zimbabwean provinces does not deviate that strongly from the line of even distribution, while the Gini coefficient was 0.3067 in 1982 (CSO, 1985, p. 53-54).

This also points at one of the weaknesses of these methods of calculating measures of concentration: they are very sensitive to the spatial level of disaggregation. Choice of boundaries and spatial units affects the outcome to a very high degree. Some caution is thus called for.

A final issue concerning population distribution is the distinction between rural and urban population. Definitions as to what constitutes an urban centre differ. According to the 1982 population census of Zimbabwe an urban area is a centre of 2500 people or more[20]. Obviously rural and urban population densities

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[20] This differs from the 1969 definition, according to which any locality with at least 150 people, the majority being adult males employed in non-agricultural occupations, was considered as urban (see CSO, 1985, p. 53).

differ, but also other demographic, economic and social characteristics, not only between rural and urban areas, but also between urban areas of different sizes. For that reasons urban analysts and planners tend to differentiate between various urban size classes. The size distribution of cities and towns in Zimbabwe is given in table 20.

Table 20. Population size distribution of cities and towns, Zimbabwe, 1982.

Urban size class	No of cities and towns	% of urban population
2500 - 4999	30	5.46
5000 - 9999	13	4.46
10000 - 19999	7	5.28
20000 - 49999	8	13.16
50000 - 99999	2	7.65
100000 - 499999	2	30.20
500000 +	1	33.79
	63	100.00

7.2. Carrying capacities

In rural planning, but also in other applications[21], the concept of 'carrying capacity' is often used to determine maximal population densities in, or use of, a particular area. Carrying capacity refers to the maximum number of users that can be sustained by a given set of land resources (Johnston et al., 1986, p. 39). The concept merits attention here for two reasons. First, because it is somehow confusing, and if not properly applied can do more harm than good in planning practice. Second, because once the carrying capacity of an area is approached or exceeded, it will have all kinds of repercussions to demographic aspects like migration and population projections.

In agricultural areas the carrying capacity is determined by the quality of the natural environment (soil characteristics, amount and variability of precipitation, relief etc.), by technological progress and by the farming characteristics in the area. With respect to the latter, there is a steady increase in carrying capacity from hunter-gatherer systems to modern agriculture. Table 21 gives a general idea of the carrying capacity of different farming systems. It assumes one grain harvest per year and an average need of 250 kg grain per person per year. If double cropping becomes feasible, for instance through irrigation, then the carrying capacity will be increased considerably.

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[21] For instance in planning for recreation and tourism, like the number of daily visitors to be allowed in a National Park.

Table 21. Carrying capacity of different farming systems

Farming system	yield (kg/ha) agricultural land	persons per km² agricultural land
Hunter-gatherers (savanna)	-	0.2
Hunter-gatherers (rainforest)	-	2
Shifting cultivation	1250	50
Semi-permanent agriculture	800	100
Permanent agriculture (traditional)	1000	400
Permanent agriculture (modern)	4000	1670

Source: Flach, 1980, p. 37

These figures give general guidance only, but the main point is that the capacity is dependent on the farming system, which might be dynamic itself. More specific carrying capacities have to be established according to particular local circumstances. In Zimbabwe several authors have written on carrying capacities for the various agro-ecological zones, assuming constant agricultural practices. Figures based on Whitlow (1980) and Whitsun Foundation (1983) are provided in table 22, which also shows that opinions concerning safe carrying capacities may differ substantially.

Table 22. Estimated carrying capacities (people per km²) per agro-ecological region in Zimbabwe

Region	Carrying capacity according to: Whitlow (1980)	Whitsun Foundation (1983)
I	25	60
II	20	60
III	15	45
IV	10	30
V	5	15

Sources: Whitlow (1980, p. 178), Whitsun Foundation (1983, p. 153)

The Save study (Campbell et al., 1989) considered three scenarios to arrive at estimates for carrying capacity in Chiweshe ward, Buhera District. This area mostly falls within natural region IV, with a small part in region III. The agricultural system is sedentary with predominance of livestock rearing, supplemented by growing of maize, millet, groundnuts, sorghum and cotton. The method compared energy production potential -as a nutritional indicator- and consumption needs in kilo calories (kcal). The first scenario was based on current agricultural practices and concluded that the area could safely sustain 16 people per km², taking recurrent droughts into account. The second scenario assumed that the combination of crops remained unchanged, but that the area under cultivation increases to 25% of the total land. This is considered to be the maximum for a livestock-dependent system. In addition, it considered an increase in yields, equivalent to those in large-scale commercial farming areas. The resulting carrying capacity would be 86 persons per km^2. The third scenario assumes the same yields as scenario two, but the land under cultivation was considered to increase to 50% of the total area available. This would double the carrying capacity to 172 persons per km^2. But, it was added, this is a most unrealistic scenario and can not be taken seriously. Population density in Chiweshe in 1982 was 29 persons per km^2, well above the carrying capacity at that moment. This will affect the ecosystem through land degradation, erosion and overgrazing, thus further reducing the carrying capacity, according to the study. Such a situation is not sustainable and some kind of adaptation should take place, in a demographic and/or in an economic way. Demographic adaptations refer to out-migration from the area, a decrease in fertility levels, or an increase in mortality (due to Malthusian population checks). An economic adaptation could be made through a change to another farming system as proposed in scenario two. It could also involve more non-agricultural activities or a heavier reliance on remittances from labour migrants.

The above example has demonstrated that the concept of carrying capacities is a relative one. It is dependent on the type of land management, on the characteristics of the land and its users. Moreover, the actual calculation of carrying capacity is complex and invariably involves some subjective judgments on minimum nutrition level and productive potential, as well as an arbitrarily selection of a threshold level, beyond which environmental change becomes unacceptable. Finally, an even more fundamental point of criticism on the concept needs to be mentioned. This concerns the fact that carrying capacity relates agricultural land directly to the number of people it can sustain. But people can earn a living in many other ways than through agriculture alone. Some areas (mining areas, urban agglomerations) sustain large numbers of people although no crop is grown in the area. Through trade with other areas sufficient food can be secured. The <u>economic capacity</u> of these areas is therefore of much greater importance than the mere (agricultural) carrying capacity. For a discussion on carrying capacities in Sub-Saharan Africa, see also Mahar (1988).

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